INSECTS INJURIOUS TO DECIDUOUS SHADE TREES AND THEIR CONTROL

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HEALTHY APPEARANCE is of the utmost importance in shade trees, and no agency is more potent in marring the appearance of these trees than are insects. A defoliated or otherwise bedraggled shade tree is not only worse than none at all but, when a result of insect injury, it is a menace to the health or life of similar trees in the neighborhood.

Practical ways of controlling most of the injurious shade-tree insects are known. This bulletin discusses the more important insects affecting deciduous shade trees in the eastern two-thirds of the United States with the exception of the gipsy moth and the brown-tail moth and gives the remedies for them. The gipsy moth and brown-tail moth and their control are considered in Farmers' Bulletin 845.

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INTRODUCTORY.

WHY INSECT INJURY IS PREVALENT ON SHADE TREES.

The original home of the trees we plant along our highways and byways is the forest. There, whatever disadvantages they are exposed to, they have acquired a certain degree of resistance to and immunity from insect and probably other normal enemies. Transplanted to our streets, parks, or home grounds they are relieved of the keen competition and other adverse conditions of wild forest life but lose most of the natural advantages of their customary association—sun and shade, moisture and humus—and their proper growth is hampered besides, especially in our cities, by a variety of unfavorable conditions. Hard packed ground, frequently disturbed, often poisoned with oils or gases or charged with electric current, and uncertain or erratic water supply handicap the roots, while constant struggle with thoughtless or reckless man and greedy beast, limited sunshine, and other vicissitudes above ground render their struggle for existence uphill work indeed. Trees so hampered lose much of their native power of resistance and are thereby rendered inviting, easy prey to a variety of disintegrating agencies most prominent among which are insects. This is promptly reflected in their appearance, which is a prime consideration in the usefulness of shade trees. No kind of tree or any part of it is wholly immune from insect pests. Indeed, some parts of trees harbor a large variety of them, and trees are known to be subject to more or less severe attack by hundreds of kinds of insects. In a world thus swarming with these creatures,

intent on sharing in practically every one of his enterprises, it is inevitable that man should have to contest every foot of his ground, especially when he adapts nature to his needs, convenience, or comfort.

EXTENT OF INSECT INJURY TO SHADE TREES.

As the growing season advances all shade trees apparently otherwise perfectly healthy will be found on more or less close inspection to show cumulative signs of insect injury, particularly in their foliage. This is inevitable when we consider the great variety of plant-eating insects they harbor. In most cases the injury is too insignificant for treatment. But from this point on the other extreme is not infrequent, when, as a result of abnormal increase of some insect species, the injury may be so severe as to menace the very life of its favorite host tree. Indeed, instances on record are not uncommon in which entire rows of certain trees and most trees of a given kind in communities and regions have been killed by insect pests within a few seasons. Certain trees are more subject to attack and injury and by a greater variety of the seriously injurious insects than others, so that, as a result of a process of selection, such trees are either no longer planted or sparingly, especially where their serious insect enemies are dominant. On the other hand, some of the injurious shade-tree insects, like the white-marked tussock moth, are almost omnivorous, so that practically no deciduous shade tree is immune to their attack and very severe defoliation.

PRIMARY AND SECONDARY INSECT INJURY.

Insects injurious to shade trees may be roughly grouped in accordance with the condition of health of the tree they normally attack. Certain species—and this is especially true of leaf-chewing insects—show a decided preference for perfectly healthy trees. Others—and this is the case with most wood and bark boring insects—can inhabit trees only when the health of these has been previously impaired, whatever the agency responsible for this. These more or less distinctive groups of insects are designated as *primary* and *secondary*, respectively. From the viewpoint of control it is as important to know to which of these an insect found on a tree belongs as it is to know whether it is injurious, beneficial, or indifferent. It is wasted effort to proceed against an insect, even if found injurious, if its presence is conditioned by previous or primary injury or death of the tree. It is the cause of this primary injury that must be discovered and dealt with. On the other hand, there are still a number of insect species that are primary under some conditions and secondary under others, so that they can not be definitely assigned to either group.

GENERAL LIFE OF INSECTS.

Like other living objects, the insects we encounter are the offspring of parents that preceded them—males and females in most cases. Between the time of hatching from the eggs and maturity the growing insects molt, or cast off their skins, three or more times. In some forms, as in the aphids and bugs generally, these immature stages differ little from the adults. In others, as in the beetles, moths, etc., the immature insects, or *larva* stages, as they are called, differ radically in appearance from the adults, and there is, besides the *egg*, another nonfeeding stage or form, known in moths and butterflies as the *chrysalis* and in all of them as the *pupa*. The pupa or chrysalis stage immediately precedes that of the *adult*. The larva of the moth or butterfly is generally known as a *caterpillar*, that of the beetle as a *grub*, that of the fly with two clear wings as a *maggot*, and that of the fly with four clear wings as a *grub*, *slug*, or *false caterpillar*. These forms generally differ sufficiently among themselves for fairly ready assignment to the proper group. Any one of them, except the egg and pupa, may be the injurious form or the one in which the given insect is most advantageously fought; the two—the injuring form and the one treated—not necessarily always being the same. Intelligent control of insect injury, therefore, involves at least a general knowledge of the habits of insects. Among these none is more important than the feeding habit, since this determines largely the control measures to be adopted.

MANNER OF INJURY AND PARTS OF TREE AFFECTED.

In the great majority of cases the mouth of the injurious form of the insect is adapted for feeding either by sucking the sap of the plant (plant-lice or aphids, scale insects, etc.) or by biting off bits of the leaf, bark, or wood (caterpillars, slugs, beetles and their grubs, etc.). The work of the biting insects usually can not be mistaken and, in the case of those feeding on the outside of the host, is often a guide to the remedy, even when the insect is not caught in the act of eating. The sap-sucking insect, on the other hand, must be discovered and its identity or at least the group or family to which it belongs ascertained before the most suitable remedy can be determined.

Injury by either group of insects is manifested in many different ways. Thus, the fine rootlets may be eaten up and the larger roots barked or bored; the trunk and larger branches may be tunneled or their sap sucked; the twigs may be deformed or cut off; the buds and leaves may be deformed; the leaves may have pieces bitten out of them or they may be skeletonized or mined. Some kinds of insects make their home and feed on a large variety of plants; many other kinds, however, utilize only one part of one kind of plant for sustenance.

NATURAL CONTROL OF SHADE-TREE INSECTS.

One of the forces which affects insects adversely or otherwise is the weather, this depending upon whether it favors the host tree or the insect. Directly engaged in checking undue multiplication of any given insect are parasitic plants (fungi and bacteria), birds and other vertebrates, spiders, mites, and insects. The insect enemies of insects are usually the most powerful and effective agency in the reduction of a noxious insect. All stages of an insect, from egg to adult, are subject to their attack. These insect enemies operate in two ways, according to their build and habit. Some of them are predacious, in that they seize their prey and eat it either by sucking it dry or by devouring it bodily (fig. 1). Ladybirds are among our best friends among predacious insects. Plant-lice or aphids particularly, but also scale bugs and other soft-bodied insects, are to their liking. Their active young as well as adults feed on these insects. Lace-wing flies, numerous bugs, and certain mites and spiders are among the other recognized predacious insects man has learned to regard with favor for their active feeding on injurious insects. The other group is known as parasitic insects (figs. 2, 3). These are by far the most numerous in variety. By special adaptations some of them are capable of prodigious multiplication and their presence has again and again been found to have saved plants from destruction in situations where man, left to his own devices, was helpless.

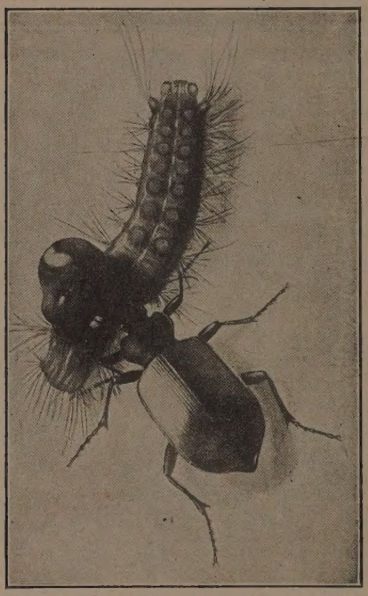

FIG. 1.—Caterpillar of gipsy moth (*Porthetria dispar*) attacked by the Calosoma beetle, *Calosoma sycophanta*. (Burgess and Collins.)

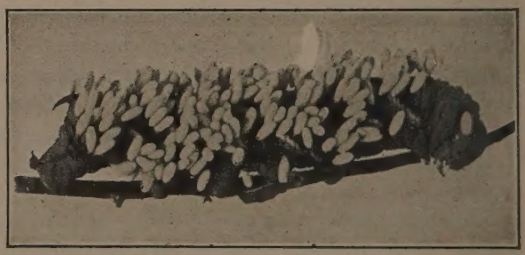

FIG. 2.—Sphinx caterpillar bearing cocoons of small, four-winged waspike parasite. (Quaintance and Siegler.)

The work of these beneficial insects brings it about that no native insect is ever present in destructive numbers for longer than a year or two, being by the end of that period greatly outnumbered by its enemies and rendered practically harmless. This is particularly noticeable in insects feeding on leaves and on the outside of the plant generally. This is true of all native insects, but not of those that have reached our shores from abroad. In the great majority of cases these were not accompanied by their home enemies, and this accounts for their uninterrupted destructiveness during long periods of time, generally until our native insect parasites and predators develop a taste for them, or until their more effective home enemies have been discovered, imported, and established in their new home, or until these have reached us as accidentally as did their hosts.

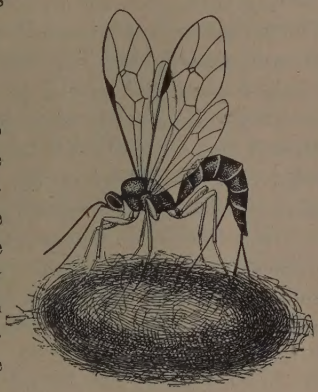

FIG. 3.—Ichneumon fly, Itoplectis, in the act of egg-laying on cocoon of apple-tree tent caterpillar. Enlarged. (Fiske.)

PREVENTION OF INFESTATION.

Many shade-tree pests are likely to reach the community by way of the nursery stock. It is imperative, therefore, to insist that young trees be thoroughly cleansed before they are taken from the nursery and certainly before they are planted. Inspection alone, however, can not always be depended upon, for some insect pests are very minute and are apt to hide beyond reach of eye or lens. Fumigation with hydrocyanic-acid gas is at present in general practice in nurseries and is the most reliable means of freeing stock from infestation. If a tree is clean and uninfested at the start, it has stored up vitality which will enable it more successfully to resist subsequent attacks.

CONTROL, PART OF ROUTINE.

Just as the potato grower in sections of the country invaded by the Colorado potato beetle considers spraying a regular, essential part of successful potato culture, so the municipality must learn to regard regular, periodic inspection of trees for evidence of insect injury, and treatment for it, as necessary to the proper care of its shade trees. The enlightened, efficient tree warden, after a little experience, systematizes this work and dovetails it in with his other duties in such a way as to utilize the labor at his command to best advantage without neglecting other important work. Thus, careful examination

of the trees while they are being trimmed, to ascertain the presence or absence of their customary insect enemies and their abundance or scarcity, is good practice and should lead to discovery of many of the insects that are, or in course of the following summer will be, giving trouble. Especially is this true when the warden and his help are familiar with the principal types of shade-tree insects and their more important habits and forms.

TREE "DOCTORS" OR SURGEONS.

The work of the experts on tree pests in the State and Federal Government services is limited to the study of the causative organisms, the discovery and determination of practical methods of controlling them, and the publication of these for general information. The actual work of controlling the pest is thus left to the individual or community, and the limited knowledge of the causes of tree troubles possessed by the general public and the frequent necessity of using rather costly spraying outfits for the control of insects and diseases has created a call for the private enterprise of experts. This requires a knowledge on the part of the expert of the fundamental facts of economic entomology and particularly of the more common injurious insects to be encountered on the trees and the remedies for them as established by the experts in the Government service. His knowledge must, of course, be coupled with integrity, and he must be equipped with adequate spraying and other outfits.

THE CITY OR COMMUNITY ENTOMOLOGIST.

The extension of tree, shrubbery, flower, and vegetable planting in and around cities, both in private yards and along highways, with the attendant insect problems on the one hand and the numerous health and sanitation questions in which household and other insects enter as a vital link in the transmission of disease, point to the advisability for such communities of engaging specialists—entomologists they are called—to look after their individual and collective insect problems. The services of such specialists would more than pay for the outlay in the improved health of the citizens and their surroundings, and especially in the prevention of insect-borne epidemics, like malaria, typhoid fever, etc., as well as defoliation and other destruction of plant life.

STATE AND FEDERAL GOVERNMENT HELP.

Every State and Territory in the Union maintains a staff of competent entomologists glad to assist every citizen in the struggle with insects. The Federal Government does likewise. All inquiries on insects receive ready, intelligent, scientific attention at the hands of these officers, and the information furnished is as complete and accu-

rate as can be given. The labors of these specialists are greatly simplified, however, and the answers can be more direct and prompt if inquiries are accompanied by specimens of the insect, its work, or both, and a description of the extent of the injury and other pertinent information. These officials are glad to receive specimens and information, as it often adds to the knowledge of the distribution of the insects, their habits, etc. A note on the results of treatment is also always welcome.

DIRECTIONS FOR PACKING AND SHIPMENT OF SPECIMENS OF INSECTS AND THEIR WORK.

To receive specific information on insects, insect injury, and remedies promptly—

(1) Address inquiries and specimens to the State entomologist of your State or to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C. This bureau is the only organization in the Federal Government service that is charged with the study of insect problems, so that correspondence on such matters must reach this bureau before it can be given proper attention. Addressing communications to any other office only delays matters.

(2) *The name and address of the writer* should appear plainly on wrappers. *Specimens of live insects and their work*, preferably fresh, should accompany inquiries and should be packed about as follows: (*a*) *Wood and bark borers* are best left in their burrows and the wood or bark containing them cut into convenient sections, tied, and wrapped in two thicknesses of stout paper; (*b*) *leaf-eating insects* (separated by kind, if more than one, to prevent cannibalism), in tight wooden or tin containers or mailing tubes manufactured for the purpose, stocked with their favorite food (holes are unnecessary); (*c*) *underground insects*, in earth; (*d*) *scale insects*, attached to the bark or leaf; (*e*) *leaves and other small specimens* showing insect work inclosed with letters.

When more than one kind is sent, each should be accurately labeled with locality, name of sender, and a number or letter for ready association with corresponding marks in letter or note and with one another. Labels for insertion with alcoholic specimens should be written with soft pencil. Tight, stout containers, properly wrapped, addressed, and tied, prevent escapes, breakage, and loss in transit. Tags must be securely fastened to packages.

(3) *Notes.*—It is very important that specimens be accompanied by information giving as accurately as possible (*a*) name of host tree and part attacked, (*b*) locality, (*c*) date of collection, (*d*) character and extent of injury, (*e*) facilities for disposal of infested timber, and

(*f*) any other information that may help in identifying the insect and determining the proper remedy or control measure suitable to the condition of the correspondent. Notes should readily correspond to labels on specimens, and may be separate or embodied in the letter.

(4) *Shipping specimens.*—Packages not exceeding 4 pounds in weight are most conveniently and cheaply sent by parcels post. Bulky packages may be sent by freight; fragile, by express. They must always be sent prepaid unless otherwise authorized.

THE PRINCIPLES OF SHADE-TREE INSECT CONTROL.

As elsewhere stated, the feeding habit of the insect that is doing the injury is the main factor in determining the kind of remedy to be applied. This is particularly true of the insects that feed in the open, i. e., above ground and on the outside of the plant. In most such instances the principle is very simple: We poison the food of the insect that bites its food before swallowing it and kill the sap-sucking insect with external applications—*contact insecticides* as they are called—which are usually caustic or oily liquids. In a great many cases, however, and especially in insects that live in the interior of the plant tissue, like leaf-miners, gall-makers, borers, and underground workers, be they biting or sucking insects, our method of attacking them must necessarily be different. A vital principle of successful insect control is *wholesale destruction* of them. In emergencies, however, and especially where a single insect is capable of doing serious harm, we do not hesitate to undertake their destruction singly, as in the case of root or stem borers. Again, we often find through a knowledge of their habits that some biting insects, for instance, are more cheaply and effectively fought in some other stage of their lives than in that in which they feed; for example, the destruction of the white-marked tussock moth in the egg stage.

It is evident from what has been stated above that in spraying promptness and thoroughness are vital elements. The earlier in its life the insect is killed the more quickly it is killed and the less harm it will have done; the more completely the foliage is covered with spray the more certain is the early killing of the insects and the more of them will be killed. Likewise, with the sap-sucking insects the more thorough the application the greater the number of the insects that will be hit and killed. *Thoroughness means the complete covering of the insect's food in one case and of all of the insects in the other.*

TREE INJECTIONS: WORTHLESS OR WORSE.

A word on the subject of tree injections is imperative. Perhaps in no other respect are unsophisticated tree owners more imposed upon than in the matter of injection of various cure-all preparations under

the bark. Suffice it to say here that *such treatments are entirely without merit* in controlling insects and often are decidedly injurious to the trees treated.

THE STOMACH-POISON SPRAYS.

The standard poisons used at present for killing chewing insects are *arsenate of lead* and *arsenate of lime* (*calcium arsenate*). Both are procurable in the market, usually in seed stores, and come in either paste or powder form. The powder form is preferable for a number of reasons. While these poisons may be prepared at home, it is usually more convenient to buy the prepared article, which only needs to be stirred into water or Bordeaux mixture before being used. The directions for dilution are usually given on the containers. The amounts to be used in small quantities are given in Table I, page 30.

Other poisonous substances are used occasionally, while some, like Paris green, were used extensively, almost exclusively, until superseded by arsenate of lead and arsenate of lime. The lower cost and greater fineness and adhesiveness of the last two make their use most general now.

Being violent poisons, these substances should be stored and handled with due caution, especially as regards live stock and children.

THE CONTACT SPRAYS.

As elsewhere stated, contact sprays are used to kill sap-sucking insects, like scale bugs, aphids or plant-lice, etc. Death is produced by the coating and clogging of their breathing pores, by affecting the nervous system, or by caustic action on the tissue of the insect, or by combinations of these. Lime and sulphur compounds, soaps, petroleum oils, and tobacco extracts are the active agents in these preparations.

Lime-sulphur, *miscible oil*, *kerosene emulsion*, and *40 per cent nicotine sulphate* are contact sprays. With the exception of kerosene emulsion, which must be prepared at home, all of them are procurable commercially, where each is sold under a variety of proprietary names. All that they require to be made ready for application is to be stirred into water, with the addition of a little soap in the case of the nicotine. Directions for dilution are usually printed on containers and should be followed carefully. For small quantities see Table I, page 30

LIME-SULPHUR.

Lime-sulphur, as an insecticide, is used almost exclusively against the so-called armored scale insects, like the San Jose and oyster-shell scales, and principally as a dormant or early spring spray. It is the

cheapest of the scale-killing sprays, but unfortunately it *discolors paints* and, as most shade trees are located in greater or less proximity to buildings, its use is limited to trees not so located and to nursery stock. Wherever practicable to apply it with a paint brush, its cheapness may offset the labor cost. The concentrated preparation as bought should have a density of about 33° on the Baumé scale. At this strength it should be used at the rate of 1 pint in each gallon of spray. See Table I, page 30.

MISCIBLE OR WATER-SOLUBLE OILS.

In shade-tree work the miscible oils are used especially against scale insects and are the only ready-prepared substances available on the market that will effectively control all kinds of scales as does kerosene emulsion. These preparations come under a variety of proprietary names and vary somewhat in strength, so that directions for dilution as given on the containers must be followed carefully. The miscible oils are primarily winter sprays, being used at this season on account of the absence of foliage, which they are apt to injure. Since they are used principally in the control of scale insects, their application while the plants are dormant is most satisfactory anyway, because, in the absence of foliage, the insects are more easily reached, the covering with spray can be more complete, less spray solution is required, and the spray can be more safely applied at greater strengths, thereby killing the insects with greater certainty.

CREOSOTE OIL.

Creosote has been found very useful in daubing tussock-moth eggs. It is apt to thicken in cold weather and is then thinned with turpentine.

KEROSENE.

Kerosene is also useful on a mop at the end of a pole for daubing tent caterpillars and webworms or tussock-moth eggs, or, with proper caution, the kerosene on the mop may be lit and used as a torch to burn out the caterpillars in the tent or web.

KEROSENE EMULSION.

Kerosene emulsion is a standard contact spray, composed of kerosene, soap, and water in certain proportions. By varying the proportion of water, this spray can be used both summer and winter against scales and soft-bodied insects. The emulsion, as the concentrated mixture is called, is likely to deteriorate in storage, by breaking up into the kerosene and soap solution from which it was made. For "homemade" emulsion the best procedure is to prepare a stock

mixture first and then dilute it as needed. This stock mixture may be made up in quantities, and if properly prepared it should keep for some time.

Kerosene-emulsion stock is most conveniently prepared as follows:

Kerosene	gallons	2
Fish oil or laundry soap (or soft soap, 1 quart)	pound	½
Water	gallon	1

Put the water and soap into a wash boiler or similar vessel and heat until the water boils and the soap is dissolved; remove from the fire, add the kerosene, and stir vigorously for about five minutes until the mixture is creamlike in consistency. A convenient way to make the mixture thorough is to pour the soap solution and kerosene into the tank of the spray pump and, through the nozzle, to pump the mixture back into the tank for several minutes.

For spraying, this stock mixture is diluted with water, which is best done at the time and in quantities needed. For summer spraying, on trees in foliage, add 5⅔ gallons of water to each gallon of the stock preparation. For winter use, on dormant trees, 1⅔ to 2⅓ gallons of water are added to each gallon of the stock. For smaller quantities see Table I, p. 30.

POISONED CONTACT SPRAY.

In this preparation the contact solution is used as a conveyer of the poison in situations where the ordinary water solution of the poison could not penetrate. It was specially devised to reach and kill borers while they are still feeding in the bark, and is prepared as follows:

In each gallon of water used for diluting the contact preparation, be it kerosene emulsion or water-soluble oil, dissolve 1 ounce of sodium arsenite, before making the mixture. Sodium arsenite is readily soluble in water and is procurable in drug stores. The crude or commercial product, which is cheaper, will answer the purpose. This preparation is injurious to foliage, which should be borne in mind when applications are made with it.

NICOTINE SULPHATE.

Nicotine sulphate is a specific remedy for aphids or plant-lice, but other soft-bodied insects can also be killed with it. It is a liquid extract of tobacco procurable in a variety of stores under a variety of trade names and varying in strength. The preparation is merely diluted with water before use, and the proportions are usually given on containers. The 40 per cent nicotine sulphate is the most commonly available; although when properly diluted, any strength of the stock preparation will answer. It is necessary to add 1 ounce of soap to each gallon of the spray to insure its spread and adhesion.

CARBON DISULPHID.

Carbon disulphid is a heavy, ill-smelling liquid, procurable in drug, seed, and other stores. It evaporates readily at the normal temperature, and as its vapor is heavier than air, it sinks. *It is highly inflammable and has a poisoning effect when inhaled freely, so that caution in handling it is necessary.*

In shade-tree work it is used for killing borers, being injected by means of an oil or other squirt can or dropper into the borer opening, the hole being promptly plugged with putty, grafting wax, or similar substance. In similar manner it may be used against carpenter ants.

FISH-OIL OR LAUNDRY SOAP.

Fish-oil soap, sometimes known as "whale-oil" soap, is procurable commercially and is an effective insecticide for such insects as aphids, scale bugs, and other sap-sucking kinds. Common laundry soap may also be used for this purpose. For summer spraying, dissolve 1 pound of the soap in 3 to 4 gallons of water. For winter spraying on scale insects, dissolve 2 pounds of the soap in each gallon of water over the fire and apply the spray before the solution is cold and congeals, which it is apt to do in this concentration.

Soap has other uses in the treatment of trees. Thus, with nicotine solutions it is used as a "spreader" or adhesive (see p. 13). In connection with injections of carbon disulphid it may be used to plug the treated holes to prevent loss of the fumes.

TREATMENT OF TREE WOUNDS.[1]

Tree wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, horses, vehicles, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. When a limb is cut off, the edge of the bark and the cambium should be coated with shellac as soon as the surface is sufficiently dry to permit it to stick, otherwise the value of the shellac is practically lost. The wound is then ready to be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined in a mixture containing about one-third creosote and two-thirds coal tar. One coat of the mixed materials may be sufficient, but if not, a heavy application of the coal tar should be used, and the surface recoated

[1] Adapted from Farmers' Bulletin 908.

whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, while not as satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces.

FILLING TREE CAVITIES.[2]

Decayed scars and cavities in the trunk or limbs are frequently infested with wood-boring larvæ or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees, but they afford an excellent winter harbor for certain injurious insects. As noted elsewhere (p. 16), cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities may be filled with cement and the condition of the trees materially improved.

The first operation is to remove all of the decayed wood, and this can be done by means of a gouge, chisel, mallet, and knife. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. As soon as the cambium has been cut to a proper distance it should be covered with a coat of shellac. After the cavity has been thoroughly cleaned out it should be treated with creosote and coal tar, as described under the preceding heading, and it is then ready to receive the permanent filling.[3]

PRUNING AS RELATED TO INSECT INJURY.[4]

Certain twigs and branches, when heavily infested with or injured by insects, frequently can be removed to best advantage in the course of pruning operations. Also, in the work of pruning, thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In case of severe insect injury, large trees may sometimes be severely cut back or "dehorned" to advantage. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects or punctured by the periodical cicada, or tree-hoppers, etc., usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later.

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[2] Adapted from Farmers' Bulletin 908.

[3] For full information on this subject, see "Tree Surgery" by J. F. Collins, Farmers' Bulletin 1178, U. S. Department of Agriculture.

[4] Adapted from Farmers' Bulletin 908. The general subject of pruning shade trees is discussed in Bulletin 816, U. S. Department of Agriculture, and in Farmers' Bulletin 1178.

All dead and dying trees and limbs should be promptly removed and burned, as they attract wood-boring insects which may become abundant and attack and injure healthy trees. When limbs of trees are being removed they should be sawed as closely to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and will afford a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 to 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the remaining stub close to the tree trunk and in line with its woody surface, taking care, however. to support the stub until completely severed.

STIMULATION OF GROWTH BY FERTILIZATION, ETC.[5]

Unthrifty trees are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, often will result in marked improvement.

MISCELLANEOUS INSECT-KILLING IMPLEMENTS.

Elsewhere in this bulletin the point was made that wholesale destruction is an essential consideration in the profitable control of insects wherever this is practicable. In the case of large trees the insects are generally beyond unaided reach and usually too numerous for profitable individual hand picking. Hence, mechanical devices of some sort, ranging from the ordinary paint or whitewash brush or pole and mop to the most complicated power drawn and propelled spraying outfit, are generally employed in this work. Local conditions and the insect involved largely determine the sort of instrument to be used in any given case.

THE PAINT OR WHITEWASH BRUSH.

In the absence of spraying machinery or for other reasons a single shade tree or small number of them requiring treatment of trunk and

[5] Adapted from Farmers' Bulletin 908.

larger branches, as for scale insects, may often be saved from serious injury or utter ruin by the application of an insecticide with a paint or whitewash brush. With proper protection of the painter's hands and face even lime sulphur, which is somewhat caustic to the bare skin, may be used to advantage, for it is considerably cheaper than other preparations, and a brush application will insure against possible injury to paints on buildings near by. The brush has also the advantage of being perhaps least costly and it is certainly the simplest tool for the purpose.

THE MOP.

The mop may consist of nothing more than a bundle of rags tied to the end of a pole. Saturated with kerosene or creosote it may be used for daubing tent caterpillars and webworms or tussock-moth eggs, which are thus killed most rapidly. If lighted, the kerosene-soaked mop may be converted into a torch and webs burned out, provided it is handled deftly so that the live wood is not burned.

TREE BANDING.

INDISCRIMINATE USE OF BANDS FUTILE.

The habit of some insects, at certain definite stages of their lives, of traveling in mass along the tree trunk has suggested the use of bands as barriers or traps. Against certain wingless female moths, also, like cankerworm moths, this method of control may be made operative. Various materials are serviceable for this purpose, gunny-sacking, cotton batting, and fine-mesh wire screen being employed and, in recent years, certain sticky substances have come into quite general use.

It is evident that the usefulness of such bands is restricted to tree-infesting insects having the habits above mentioned. Unfortunately many people have gained the erroneous impression, especially since the use of sticky bands has come into vogue, that these bands are a panacea for all tree troubles caused by insects. The result has naturally been the indiscriminate use of bands, often with the disastrous consequences that might have been expected under the circumstances. There is no royal road to insect control. The bands, even where the insect's habit allows of their usefulness, will be effective only when watched constantly so that clogging, bridging, drying up, and other contingencies may be guarded against. Banding should be resorted to only after consultation with an entomologist. Wherever applicable, the following bands are recommended:

COTTON BATTING.

Take a band of cotton batting 6 to 8 inches wide and a little longer than sufficient to encircle the trunk of the tree at a convenient height, wrap it around the tree, and tie the bottom edge of it securely, turn-

ing the upper edge down over the string so as to form a flange of loose cotton all around the tree. (Fig. 4.) It should be borne in mind that this barrier will remain effective only so long as the cotton remains fluffy, and even then, especially if the insects are very numerous, frequent examination of the band is necessary if it is to be kept in proper working order.

FIG. 4.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

WIRE SCREEN.

Wire screen may be used to trap nonflying moths like those of the cankerworms and tussock moth to prevent them from crawling up the tree. Ordinary 12-inch 12-mesh fly screen is cut on a bias into pieces long enough at the top to overlap an inch or so after encircling the tree trunk at the desired height and about 6 inches longer at the bottom. Fasten the upper edge snugly around the tree with small carpet tacks and let the ends meet on a bias, so that the looser edge of the band stands away from the trunk about an inch all around and admits the ascending insects freely. Where a number of uniform sized trees are to be banded at the same time, the wire strip may be cut up as suggested on the accompanying outline (fig. 5).

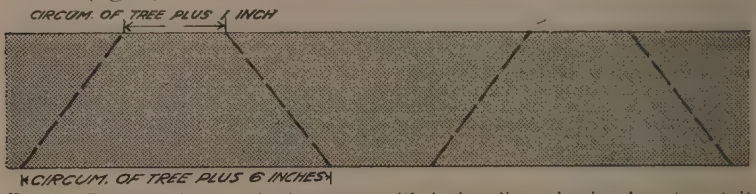

FIG. 5.—Diagram of strip of wire screen with broken lines showing how to cut it for insect guards.

These bands must be examined daily and moths collected under them crushed, as the tiny larvæ hatching from eggs they may lay will readily penetrate the screen. Because of this necessity, the use of wire bands is practicable only in limited instances.

STICKY BANDS.

Applied directly to the bark of the tree sticky bands may be injurious. The injury may be prevented, however, by applying the preparation on a strip of heavy paper. As such paper can not be made to fit snugly, cheap cotton batting may be used underneath it.

The process then is as follows: Cut a strip of cotton about 2 inches wide and wrap it around the tree trunk so as to fill all the crevices of the bark. Over the cotton place a strip of 1-ply building tar paper about 5 inches wide, draw it tightly, and tack it securely where it overlaps. The adhesive is then spread out on the paper. (Fig. 6.)

The sticky preparation is apt to become dry or covered with dust and insects and, in consequence, fail to function, so that it should be either renewed from time to time or it may be renovated by combing it so as to remove obstructions and bring the fresh material to the surface.

Sheets of sticky fly paper may be used for tree banding, in emergencies. They are best placed over bands of cotton batting, as described above, and fastened to the trunk by means of heavy twine tied tightly around the upper and lower edges.

FIG. 6.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

STICKY PREPARATIONS FOR BANDING.[6]

The market offers proprietary preparations for banding which are frequently preferred because ready for use. Where materials, facilities, and time are available, however, these preparations may be made at home. Homemade preparations offer advantages in that adulterant or harmful substances are sure to be excluded, the cost will be less, and substances may be used up that might otherwise go to waste. Following are some of the substances and mixture that may be employed for this purpose:

ROSIN-CASTOR OIL MIXTURE.[6]

Place 5 pounds of rosin and 3 pints of castor oil in a pot and heat slowly until the rosin is melted. Add more oil if the resultant is too thick.

AXLE GREASE, FISH OIL, AND ROSIN.[6]

These substances are used in Europe for the preparation of a tree-banding mixture which is reported effective. The mixture is made as follows:

Axle grease	pound	1
Fish oil	pint	1
Powdered rosin	pounds	2

[6] See also Department Bulletin 899, "Gipsy Moth Tree-Banding Material: How to Make, Use, and Apply It," which may be obtained from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

The rosin-castor oil mixture and the mixture of axle grease, fish oil, and rosin have been tested by the Bureau of Entomology in New England for banding purposes but are unsatisfactory in that region.

Heat the axle grease in a cooking vessel of at least a gallon capacity until all the water in it is evaporated. Without removing this from the fire, stir in the fish oil, followed by the powdered rosin, a little at a time. When the latter is dissolved, remove from the fire, and the mixture is ready for use next day.

PRINTER'S INK.

Refuse printer's ink, sold as "tree ink," may be used for tree-banding purposes, but it should be mixed with a heavy oil to prevent it from drying too rapidly.

SPRAYING OUTFITS FOR SMALL OPERATIONS.[7]

HAND ATOMIZERS.

For spraying a few plants or very small trees, hand atomizers (fig. 7) may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart.

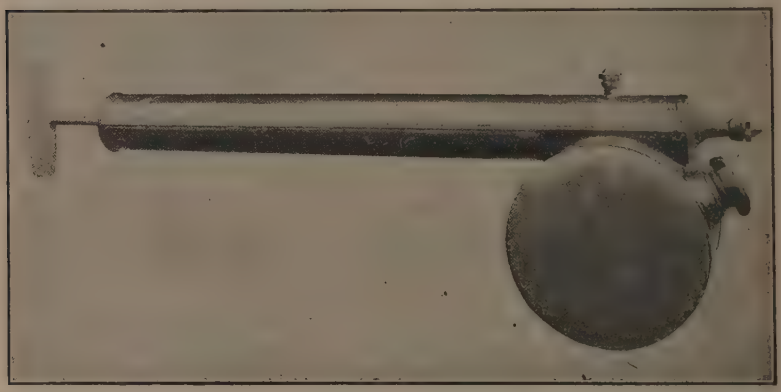

FIG. 7.—Hand atomizer, useful for spraying small plants or low-growing trees. (Quaintance and Siegler.)

SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 8) are now most frequently used in small-scale spraying, and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4 gallons. They are carried by means of a shoulder strap. In the better types agitation is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank, and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. The tank is usually emptied by three to four pumpings of a dozen strokes each.

[7] Adapted from Farmers' Bulletin 908.

BARREL PUMPS.

The barrel hand-pump outfit (fig. 9) has a capacity of about 50 gallons, and may be used to advantage on a limited number of trees. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and the whole outfit placed on skids or on a wagon. On hilly land it is preferable to have the barrel in a horizontal position.

FIG. 8.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying. (Quaintance and Siegler.)

DOUBLE-ACTION HAND PUMPS.

The double-action hand pumps (fig. 10) usually are employed in connection with spray tanks of greater capacity than a barrel, as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform, and placed on top of the tank or on a platform at the hind end of the wagon. A suction hose extends into the spray tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer.

A common defect is lack of adequate facilites for agitation, although tanks are available in which this deficiency is corrected to some extent.

SPRAYING OUTFITS FOR LARGE OPERATIONS.[8]

Spraying outfits in larger towns and cities are generally best operated by gasoline engines. In an emergency even the fire engines may be utilized for this purpose in some communities.

GASOLINE-POWER SPRAYERS.

Spray pumps, operated by gasoline engines, are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

FIG. 9.—Barrel pump, suitable for spraying a few medium-sized trees. (Quaintance and Siegler.)

The smallest power sprayers are nothing more than ordinary barrel pumps equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and at a higher pressure than will the pumps operated by hand. With the small power-outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (see title-page) are made with pumps of from two to four cylinders, having a capacity of 5 to 50 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are operated by gasoline engines of from 2 to 12 horsepower. For the four-cylinder pumps of large capacity, auto-type 4-cylinder engines of 10 to 12 horsepower are sometimes used.

[8] Adapted from Farmers' Bulletin 908.

In the extensive spraying operations in New England for the gipsy and brown-tail moths motor-truck sprayers[9] (fig. 11) have been used to great advantage.

The makes of spray machines now on the market vary a good deal in durability and efficiency. The tree warden, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements.

SPRAYING ACCESSORIES.[10]

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save

FIG. 10.—Double-action hand pump for spraying home grounds or in the small community. (Quaintance and Siegler.)

time or aid the tree warden in doing more thorough work should be provided. The equipment need not necessarily be elaborate or expensive, but should be sufficiently complete and modern so that there will be no handicap when the time to spray is at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy loss.

SPRAY NOZZLES.

Manufacturers of spraying machinery and accessories have placed on the market a large number of nozzles to which they have given

[9] Department Bulletin 480, "Solid-Stream Spraying Against the Gipsy Moth and Brown-Tail Moth in New England," contains full information on the subject and may be purchased from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

[10] Adapted from Farmers' Bulletin 908.

various trade names. Although these nozzles differ somewhat in size and style, the principle of construction is not distinctive for each.

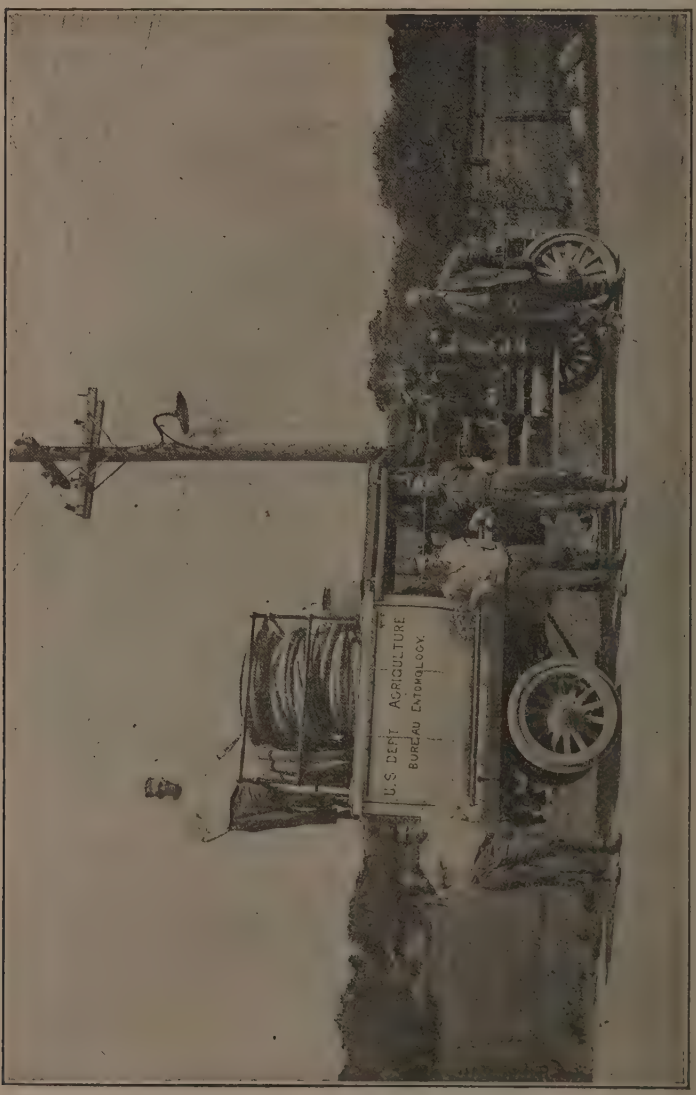

FIG. 11.—Motor-truck sprayer of the Bureau of Entomology with crew and equipment. (Worthley.)

The nozzle type most suitable for shade-tree spraying is that known as the whirlpool disk type (fig. 12). It is as well adapted for use

with small spraying outfits as with larger ones. These nozzles are usually provided with three interchangeable disks or plates, each having a different sized opening to give a fine, medium, or coarse spray. The spray material passes through a tangential opening into the eddy chamber, where it obtains its whirling motion and escapes through the opening in the disk. The disk nozzles are relatively small and compact and, owing to the absence of any appendages, do not catch in the branches of trees as happens with other designs. The coarse spray disks deliver a fairly large quantity of spray material, and can not be used satisfactorily with pumps of small pressure capacity. With the smaller spraying outfits the disks having small apertures should be used.

FIG. 12.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook. (Quaintance and Siegler.)

NOZZLE Y.

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a Y.

SPRAY RODS.

Spray or extension rods (fig. 13) are employed in order to reach the upper and inner parts of the trees. These generally consist of an aluminum, brass, or iron rod contained within a bamboo pole and are usually made in lengths of from 6 to 14 feet. Some fruit growers use an ordinary gas pipe, but the lighter weight spray rods are much more desirable.

ANGLE SHUT-OFF.

An angle shut-off, connecting the spray hose with the base of the spray rod, is a convenient device for cutting off the spray material whenever desired, as in passing from one tree to another. The angle construction permits the hose to hang in its natural position, and thereby saves the hose from wearing at the coupling. Without an angle shut-off, spray material is frequently wasted because of the inconvenience of closing the stopcock.

THE WORTHLEY NOZZLE, FOR SOLID-STREAM SPRAYING.

In the spraying of shade trees, which, when full grown, are usually quite tall and large generally, the time and labor previously required in climbing in order to reach the top have constituted the heaviest item of expense in insect control. The introduction of solid-stream spraying has largely eliminated this expense, and the Worthley nozzle (fig. 14) is a material help in the same direction. It is in effect a combination of extension rod and nozzle. With this nozzle the tops of trees 85 feet high and higher can be reached from the ground quite effectively. To break the force of the stream, so that small trees and the lower foliage of large trees may be properly sprayed, a strip of brass, slightly curved, about 10 inches long and 1¼ inches wide, known as a spreader (fig. 14, B), is attached to a brass ferrule about a foot in length, so that it can be moved up and down the tube of the nozzle. When this brass strip is slid beyond the tip the solution forcibly coming in contact with it is broken up into a fan-shaped stream, thus giving a good mist spray.

FIG. 13.—Bamboo spray rod. (Quaintance and Siegler.)

SPRAY HOSE.

Only the best grade of high-pressure hose, usually about three-eighths to one-half inch inside diameter, should be used for spraying operations. The length of the hose for spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In large tree spraying, from 50 to 150 feet, with an average of about 100 feet of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. Special conditions may require greater lengths of hose.

HOSE COUPLINGS AND CLAMPS.

It is poor economy to use light-weight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

TANK FILLERS.

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the community is provided with a convenient water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern, pond, etc.

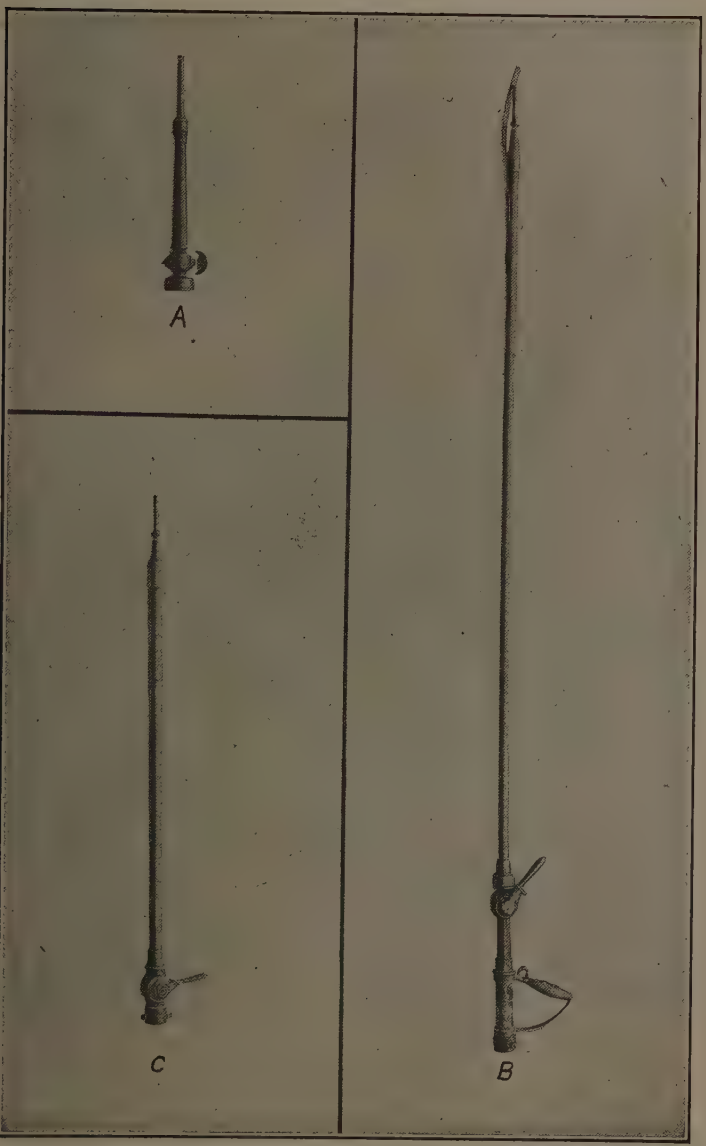

FIG. 14.—Nozzles for solid-stream sprayer. A, Old type nozzle; B, latest type, known as the Worthley nozzle, with spreader; C, smaller size, same type as B. (Worthley.)

Rotary pumps (fig. 15) connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in districts where the water is drawn from the irrigation ditches.

PRESSURE REGULATOR.

This is a useful attachment for the regulation of the pressure. By its proper adjustment a uniform spray is obtained at the pressure desired.

MISCELLANEOUS SPRAYING SUPPLIES.

The following accessories should be provided:

Scales.—A good pair of scales should be used for weighing out the spray materials. Guess-work is poor economy.

FIG. 15.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary pump tank filler. (Quaintance and Siegler.)

Galvanized buckets.—These are useful for measuring liquid spray materials, especially when gallons and smaller quantities are marked on them by means of graduating dents.

Strainer.—Before admitting spray material into the spray tank, it should first pass through a screen (fig. 16) to remove all of the coarse particles. The opening in the spray tank for filling purposes is usually provided with a removable brass screen.

Extra parts.—Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

Tools.—Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, however, such as wrenches, screw drivers, hammers, etc., should be carried in the tool box in case of need.

Help.—In solid-stream power spraying at least 5 men are required: One mechanic and driver (or chauffeur if the outfit is mounted on a power truck), three men at the hose, and one at the nozzle. If more than 150 feet of hose are used, more men will be needed.

It is perhaps not out of place to state here that, in view of the fact that spraying is practically futile unless it is intelligently done, it is not only desirable to have the help in this work intelligent and measurably well informed, but also to have the rewards of their labor sufficiently attractive to hold them to a certain degree of permanence, thereby insuring effectiveness and efficiency. In the long run such a policy will prove the cheapest and most satisfactory.

FIG. 16.—Strainer for use in removing sediment in sprays when these are being poured into the spray tank. (Quaintance and Siegler.)

SPRAY DILUTION TABLE FOR READY REFERENCE.[11]

Table I shows the amount of spray material required for a number of different quantities of spray. The rate at which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the amount of spray material required. Thus, if 150 gallons of arsenate of lead, paste, at the rate of 2 pounds to 50 gallons, is to be used, it will be noted in the table that 6 pounds is required. Again, if 100 gallons of kerosene emulsion, 10 per cent strength, is wanted and the stock solution contains 66 per cent of kerosene, it will be found by referring to the table that 15 gallons of the stock emulsion should be used.

[11] Adapted from Farmers' Bulletin 908.

TABLE I.—*Spray dilution table for ready reference. (A) For trees in foliage; (B) for dormant trees.*

	Total gallons of diluted spray material.									
	200	150	100	50	25	20	15	10	5	1
(A) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR TREES IN FOLIAGE.										
Stomach poisons.										
Arsenate of lead, paste, 2 lbs. to 50 gals	8 lbs.	6 lbs.	4 lbs.	2 lbs.	1 lb.	12.8 oz.	9.6 oz.	6.4 oz.	3.2 oz.	0.64 oz. or 1 teaspoonful.
Arsenate of lead, powder, 1 lb. to 50 gals	4 lbs.	3 lbs.	2 lbs.	1 lb.	8 oz.	6.4 oz.	4.8 oz.	3.2 oz.	1.6 oz.	0.32 oz. or 3 teaspoonfuls.
Arsenate of lime, paste, 2 lbs. to 50 gals	8 lbs.	6 lbs.	4 lbs.	2 lbs.	1 lb.	12.8 oz.	9.6 oz.	6.4 oz.	3.2 oz.	0.64 oz. or 1.5 teaspoonfuls.
Arsenate of lime, powder, ¾ lb. to 50 gals	3 lbs.	2.25 lbs.	1.5 lbs.	12 oz.	6 oz.	4.8 oz.	3.6 oz.	2.4 oz.	1.2 oz.	0.24 oz. or 2 teaspoonfuls.
Paris green, 6 oz. to 50 gals	1.5 lbs.	1.12 lbs.	12 oz.	6 oz.	3 oz.	2.4 oz.	1.8 oz.	1.2 oz.	0.6 oz.	0.12 oz. or 0.5 teaspoonful.
Contact sprays.										
Nicotine sulphate (40%), 1 to 800=½ pt. to 50 gals.	1 qt.	1.5 pts.	1 pt.	8 fl. oz.	4 fl. oz.	3.2 fl. oz.	2.4 fl. oz.	1.6 fl. oz.	0.8 fl. oz.	1 teaspoonful.
Nicotine sulphate (40%), 1 to 1,066=⅜ pt. to 50 gals	1.5 pts.	1.12 pts.	12 fl. oz.	6 fl. oz.	3 fl. oz.	2.4 fl. oz.	1.8 fl. oz.	1.2 fl. oz.	0.6 fl. oz.	0.75 teaspoonful.
Kerosene emulsion (66⅔), 10% strength	30 gals.	22.5 gals.	15 gals.	7.5 gals.	3.75 gals.	3 gals.	2.25 gals.	1.5 gals.	3 qts.	1.2 pints.
Fish-oil soap, 1 lb. to 4 gals				12.5 lbs.	6.25 lbs.	5 lbs.	3.75 lbs.	2.5 lbs.	1.25 lbs.	4 oz.
(B) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR DORMANT TREES.										
Contact sprays.										
Lime-sulphur concentrate (33° B.), 1 gal. to 8 gals	25 gals.	18.75 gals.	12.5 gals.	6.25 gals.	3.12 gals.	2.5 gals.	1.87 gals.	1.25 gals.	2.5 qts.	1 pint.
Lime-sulphur concentrate (33° B.), 1 gal. to 9.5 gals.	21 gals.	15.75 gals.	10.5 gals.	5.25 gals.	2.62 gals.	2.1 gals.	1.57 gals.	1.05 gals.	2 qts.	0.84 pint.
Kerosene emulsion (66⅔), 25% strength	76 gals.	57 gals.	38 gals.	19 gals.	9.5 gals.	7.6 gals.	5.7 gals.	3.8 gals.	1.9 gals.	3 pints.
Kerosene emulsion (66⅔), 20% strength	60 gals.	45 gals.	30 gals.	15 gals.	7.5 gals.	6 gals.	4.5 gals.	3 gals.	1.5 gals.	2.4 pints.
Fish-oil soap, 2 lbs. to 1 gal	400 lbs.	300 lbs.	200 lbs.	100 lbs.	50 lbs.	40 lbs.	30 lbs.	20 lbs.	10 lbs.	2 lbs.

Abbreviations: oz.=ounce; lb.=pound; fl. oz.=fluid ounce; pt.=pint; qt.=quart; gal.=gallon. Weights: 16 ounces=1 pound. Measures: 7 teaspoonfuls=1 fluid ounce; 16 fluid ounces=1 pint; 32 fluid ounces=1 quart; 4 quarts=1 gallon.

LEAF-CHEWING INSECTS.

GENERAL.

The life of the deciduous tree attacked by leaf-chewing insects is directly endangered by them only when they keep the tree in a state of complete defoliation for several years in succession. Fortunately this condition can apparently be brought about only by recent insect pest immigrants before our native predacious and parasitic insects develop an appetite for them. This was true not so many years ago of the elm leaf-beetle, for instance, which is only an occasional and local pest at present owing to the effective work of predacious bugs that feed on its eggs. Nevertheless, aside from disfiguring the tree for the season, defoliation tends to reduce its vitality more or less, and this often leads to its attack by other insects, principally bark and wood borers, which are much harder to combat and the injury of which not infrequently results in fatalities among trees. For these reasons, as well as the fact that it is the most easily done, it is advisable, wherever practical considerations permit, to check defoliation as soon as observed. As not every hole in the foliage necessarily indicates the presence of a defoliator this point is best first definitely ascertained before the labor and expense of spraying are undertaken. Municipalities, however, should always be prepared for such emergencies by having on hand the necessary machinery and supplies for a prompt, thorough, and quick job.

BAGWORM.[12]

Recognition of work.—Although arborvitæ and other evergreens are the favorite food of the bagworm, broad-leafed trees and shrubs are not infrequently discovered to have their foliage eaten and bearing rough looking, more or less spindle shaped bags up to 2 inches long (fig. 17). On closer examination a head and six legs are found protruding from the opening at the upper end of the bag. Badly defoliated trees during the dormant season are bespangled with such bags, although at that time most of these contain eggs instead of caterpillars.

Habits and seasonal history.—The bagworms attain full growth in the District of Columbia toward the end of August, whereupon they transform to pupæ. About three weeks later these change into adult moths, of which the females are wingless and do not leave the bag. The males alone emerge from the bags and fly in search of females, with which they mate. Immediately thereafter the female begins laying her eggs, with which she nearly fills her old chrysalis skin in the bag, wriggles out of it, and dies. The eggs thus laid pass the

[12] *Thyridopteryx ephemeraeformis* Haworth.

winter in the bag and late the following spring hatch into caterpillars, which make their way to the nearest leaf and immediately begin to feed and construct bags for themselves. The bags are made from bits of the foliage on which they feed and silk spun by them. In the latitude of Washington, D. C., it takes the bagworm a full year to complete its life cycle.

Control.—Several forms of parasitic insects prey on the bagworm, keeping its numbers within harmless bounds during most years. From time to time, however, this check fails to operate, and then artificial measures of control must be resorted to.

FIG. 17.—Twig of conifer completely defoliated by bagworms, showing bags in various stages of development. (Photo by Paine.)

It is clear from the seasonal history of the insect that if, wherever practicable, the bags be picked off the trees during the winter and burned, so many eggs will have been destroyed that the damage the following season will be limited to the caterpillars from the eggs in the few overlooked bags. A better practice than burning the bags, however, would be to confine them in a bag made of sheer or coarse material and suspended from the ceiling of an outhouse, thus allowing the issue and escape of parasites they may contain, confining the bagworms until they die, and protecting the mass from destruction by mice, decay, etc. Where hand picking is impracticable, and especially on evergreen trees, the most efficient remedy is to spray

infested trees with lead arsenate (p. 11) while the worms are feeding and, preferably, soon after they are hatched from the eggs in the late spring. For strength of spray and method of applying it see pages 20–30.

The effectiveness of the campaign against this pest will be in direct proportion to the extent to which the immediate neighborhood participates in it.

A full account of the bagworm is given in Farmers' Bulletin 701 of this Department which will be sent on request as long as the supply lasts.

CATALPA SPHINX.[13]

Recognition of work.—Catalpa trees, the only kind attacked by this insect, are often found having their leaves rapidly devoured by caterpillars which, when full grown, are conspicuously yellow and black striped, 3 inches long, with a short horn near the hind end of the body (fig. 18, *c*, *e*, *f*, *h*). Caterpillar droppings beneath a catalpa tree are another indication of their presence. In some seasons the leaves are completely stripped off entire trees or even groves by this insect.

Habits and seasonal history.—Around Washington, D. C., the insect completes two generations annually, three or four in the extreme South. On attaining full growth the caterpillars of the fall generation crawl down the trunk of the tree and into the ground where they pupate and spend the winter in that stage (fig. 18, *j*). Late the following spring the large grayish brown moths (fig. 18, *k*), known as catalpa sphinx or catalpa hawk moths, issue from these, mate, and lay their eggs (fig. 18, *a*) in batches up to about a thousand on the underside of leaves, and sometimes in smaller batches on stems and branches. The young caterpillars hatching from these feed in groups for some time before scattering (fig. 18, *b*, *b*,). They molt before reaching full growth and pupating, and vary considerably in the markings, as shown in the illustration (fig. 18, *e*, *f*).

Control.—Normally, natural agencies, such as small wasplike and flylike parasitic insects and insectivorous birds, keep this insect in check, so that it is not seen in a given locality for from one to several years. In some parts of the South the catalpa is grown specially for the purpose of attracting the sphinx moth, for its caterpillars are highly esteemed there as bait for fishing. Occasionally, however, natural agencies fail to exercise satisfactory control and then the artificial killing of the caterpillars with poison spray, like lead arsenate, becomes necessary. The method of application of the spray is given on pages 20–30.

Farmers' Bulletin 705 contains a full account of this insect and will be sent on request as long as the supply lasts.

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[13] *Ceratomia catalpae* Bdv.

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FIG. 18.—Catalpa sphinx: *a*, Egg mass; *b*, *b*, newly hatched larvæ; *c*, larva one-third grown; *d*, dorsal view of joint of *f*; *h*, full-grown dark larva; *i*, dorsal view of joint of same; *j*, pupa; *k*, moth; *l*, egg, enlarged. All natural size, except *l*. Marx del. (Howard and Chittenden.)

FOREST TENT CATERPILLAR.[14]

Manner and amount of damage it does.—Although the sugar maple is its favorite food in the North and oak in the South, the forest tent caterpillar will feed on almost any deciduous tree. Like most native insects it is very abundant and causes serious injury only during

FIG. 19.—Forest tent caterpillar: *10*, Female moth with wings expanded; *11*, male moth with wings expanded; *12*, egg belt encircling twig; *13*, side view of full grown caterpillar; *14*, cocoon in leaf; *15*, pupa; *16*, cast skins of caterpillars. (Felt.)

spells of two or three consecutive years. During these years, however, it is capable of completely stripping the foliage of deciduous trees over hundreds of square miles. The stopping of trains, due to tracks made slippery by crushed masses of caterpillars which had

[14] *Malacosoma disstria* Hübn.

wandered in search of suitable feeding or transformation grounds, has been frequently reported.

How to recognize its presence.—In early summer leaves of hardwood trees or shrubs may show signs of having been eaten by caterpillars with blue head and silvery, diamond-shaped spots down the middle of the back (fig. 19, *13*). When not feeding, these caterpillars cluster on the trunks and large limbs. In a wind they drop to the ground or hang from the tree by silken threads.

Seasonal history and habits.—On approaching full growth, about early June, many of the caterpillars abandon the tree and settle in sheltered places for pupation (fig. 19, *14*). Stones, fences, and wood piles serve their purpose. They remain in this state (fig. 19, *15*) about two weeks and early in July the pupæ turn into moths (fig. 19, *10*, *11*). A little later the females lay their eggs in bands of about 150 around slender twigs (fig. 19, *12*). By fall the young caterpillars are fully developed within the eggs, pass the winter thus, and emerge the following spring about the time leaves begin to unfold.

Remedial measures.—Between the spells of abundance this insect is kept in check by natural agencies, chiefly parasitic and predacious insects and birds as well as unfavorable weather conditions.

Destruction of egg masses, caterpillar clusters, and pupæ in season, either by hand picking and burning or by daubing with creosote or spraying with kerosene emulsion or any of the standard miscible oils on the market, will aid materially in checking the pest. Finally, in the care of choice trees and where the necessary apparatus is available early spring spraying with lead arsenate (p. 11) of the trees known to be infested, if thoroughly done, will effectively check injury for the season.

SPRING CANKERWORM [15] AND FALL CANKERWORM.[16]

Character and extent of injury.—Caterpillars, which because of the peculiar loop they make of their bodies are variously known as "measuring worms," "spanworms," or "loopers" (fig. 20), are frequently found devouring the leaves of forest and shade trees of the eastern United States. Of the numerous species of loopers the cankerworms are among the few species that attack both fruit and shade or forest trees and occasionally become so numerous as completely to defoliate trees on large areas. While as a rule healthy trees replace their foliage, repeated defoliation frequently leads to attack, especially on oaks, by bark and wood boring insects, which habitually thrive on weakened trees and ultimately cause their death. The fall cankerworm is the species usually injurious on shade trees, the spring cankerworm being principally an orchard insect.

[15] *Paleacrita vernata* Peck. [16] *Alsophila pometaria* Harr.

Appearance and seasonal history.—The cankerworm is the caterpillar stage of a moth and comes from an egg laid by the female moth, which is always wingless. The eggs of the fall moth are from 50 to 150 in number, flowerpot shaped, and laid in regular rows and compact patches which are generally exposed in rings around twigs near the ends of branches. Those of the spring moth are egg shaped and are laid in irregular batches beneath bark scales. At the time the first leaves expand in the spring these eggs hatch into caterpillars, which attain full growth in about four weeks (about June) and by a silken thread descend to the ground, there pupating a few inches below the surface. From these pupæ the moths of the fall species usually emerge and lay eggs late in the fall or during warm days in winter. The males are winged, the females wingless. Soon after emerging the latter crawl up near-by trees and bushes to deposit their eggs.

FIG. 20.—Full grown caterpillars of the spring cankerworm. (Quaintance.)

Natural control.—Cankerworms are subject to attack by a variety of insect enemies. Climbing ground beetles (fig. 1, p. 6) devour many caterpillars bodily. Small parasitic wasps and flies lay their eggs in and on the caterpillars and in the eggs of the moth, and the ensuing grubs kill even greater numbers of them. Together these insects usually succeed in keeping the cankerworms in check, but if these fail, the cankerworms become seriously injurious.

Artificial control.—It is impractical to attempt to combat these insects on trees in the forest, but shade trees can be protected as follows: (1) Advantage may be taken of the winglessness of the female by keeping the tree banded (p. 17–20) with some sticky substance or cotton bands to prevent her from ascending the trees to deposit her eggs. Such bands are most effective where applied toward the end of September and maintained in the spring until the end of May. These bands also prevent the worms that come from the undergrowth from ascending the trees. (2) Where banding has been neglected and evidence of heavy infestation is indicated by numerous perforations in the opening leaves, the foliage can be saved by prompt spraying with lead arsenate (p. 11).

ELM LEAF-BEETLE.[17]

How injurious.—The elm leaf-beetle (fig. 21, *b*) feeds on all species of elm, but the common English elm is its favorite. Wherever it is established and abundant it may, under favorable conditions, keep the elms in a constant state of partial or complete defoliation and eventually lead to their death. Hundreds of elm trees of all ages are known to have died as a result of continuous defoliation by it and subsequent attack by bark-boring insects.

Evidence of infestation.—From the time the buds burst in the spring until the leaves are fairly grown the leaves show irregular holes made by the beetles. Later in the season more of the injured leaves are skeletonized from below (fig. 21, *a*) by yellowish black to blackish yellow larvæ (fig. 21, *d*, *e*, *f*) up to half an inch in length, which may also be observed crawling along the trunk. Clusters of 5 to 20 or more orange-yellow, elongate-oval, tapering eggs standing on end (fig. 21, *c*) in two or three irregular rows occur on the underside of leaves, and naked orange-colored pupæ (fig. 21, *g*) in crevices and under scales on the bark and on the ground at the base of trees.

Seasonal history and habits.—The winter is passed in the adult or beetle condition in any suitable shelter. When the buds begin to swell in the spring the beetles issue from their winter quarters, mate, and feed upon the leaflets. When the leaves are fairly well grown the females begin their egg laying. In about a week the eggs hatch into larvæ, which begin to feed at once. Larvæ reach full growth in 15 to 20 days and transform to pupæ, which, 6 to 10 days later, change to beetles. In Washington two generations are produced annually, the eggs of the second generation appearing in July.

Control.—Whenever there is evidence that the insect is present in large numbers, spray the trees with lead arsenate (p. 11) just after the buds have burst and again two weeks later. Aim to spray the underside of the leaves. Rains soon after spraying may necessitate third and fourth applications of the poison to keep the trees fresh and green. Destroying the pupæ at the base of trees by digging up and exposing to weathering or by pouring hot water or thick soapsuds over them will assist in keeping the beetle down.

Simultaneous community action, by individuals cooperatively or by the local government, is indispensable in the work of combating this insect, because unless all trees in a community are treated at the same time the results will be unsatisfactory. Cooperative action is advisable because elm trees are usually large and require costly spraying apparatus. Treatment of individual private trees by the community outfit should be arranged for, in order that no trees may be left untreated.

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[17] *Galerucella luteola* Müll.

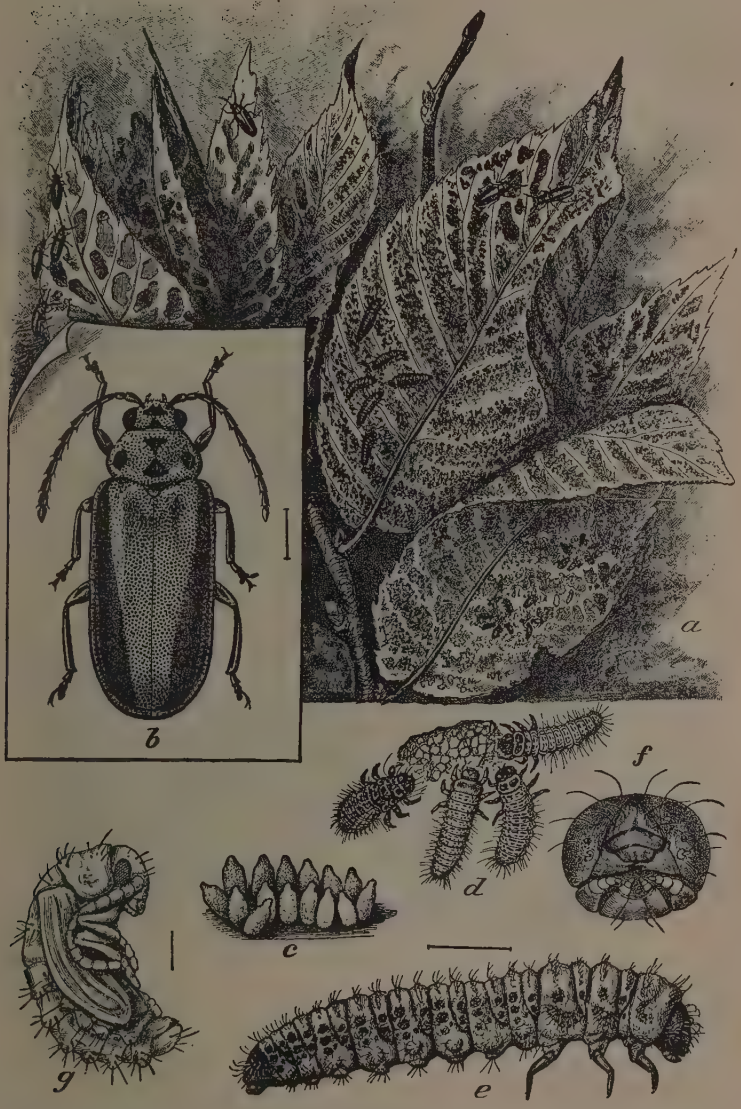

FIG. 21.—The imported elm leaf-beetle: *a*, Foliage of European elm showing method of work of beetle and larva; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *c*, full-grown larva; *f*, mouth parts of full-grown larva; *g*, pupa; *a*, Natural size; *b*, *c*, *d*, *e*, *g*, greatly enlarged; *f*, still more enlarged. (Howard.)

FALL WEBWORM.[18]

Recognition of work.—In the latter part of summer, trees are often found bearing on the limbs conspicuous webs (fig. 22) inclosing skeletonized, usually brown leaves and numerous hairy caterpillars. These are the tents of the fall webworm. The unsightly nests mar the appearance of the trees and, in years of abundance, defoliation of whole rows of trees may be caused by these worms.

Habits and seasonal history.—In Washington, D. C., the fall webworm completes two life cycles annually; less to the north and more

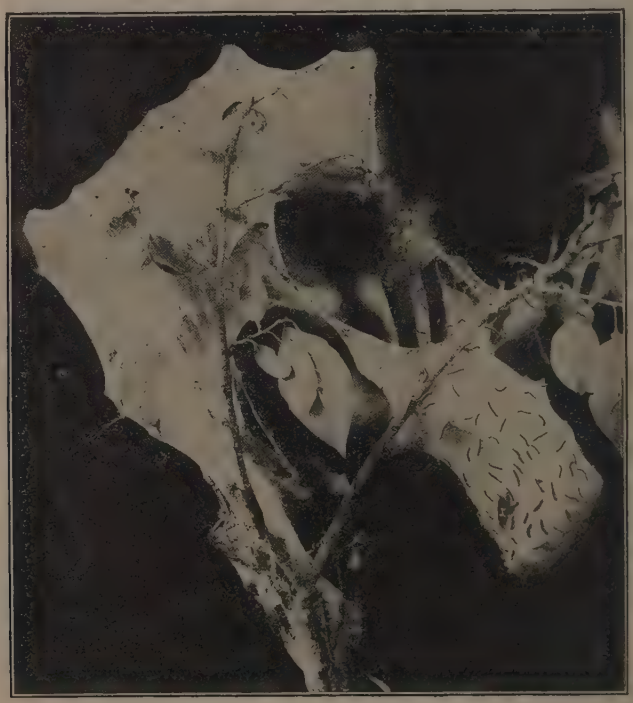

FIG. 22.—The fall webworm: Web and caterpillars. (Gill.)

to the south. It passes the winter in the pupa state in sheer silk cocoons (fig. 23) in such places as among sticks and rubbish at the surface of the ground, in cracks and crevices of tree boxes and fences, under doorsteps, and on basement walls. In May the pupæ change to moths (fig. 23) which lay their eggs in flat batches of 400 to 500 on the underside of leaves. The young worms, hatching from the eggs, feed in colonies, webbing first one leaf, then several together, and eventually covering sometimes all of a good-sized limb. These

[18] *Hyphantria cunea* Drury.

worms attain full growth in July, leave the web, and crawl down the trunk of the tree to pupate. Late in August the year's second crop of their tents is in evidence.

Control.—Natural agencies, and particularly parasitic and predacious insects, usually keep the fall webworm in check. When they become excessively abundant they are invariably attacked by a variety of insect enemies and by a veritable epidemic of diseases which destroy great numbers of the caterpillars, so that they are usually numerous not more than two years in succession.

The most practical remedies against the fall webworm are the destruction of the cocoons, burning the tents, and spraying the infested trees with lead arsenate (p. 11). The methods to be employed are the same as those recommended for the tussock moth.

FIG. 23.—Fall webworm: Moths and cocoons. Natural size. (Howard.)

WHITE-MARKED TUSSOCK MOTH.[19]

How injurious.—The white-marked tussock moth is one of our worst shade-tree pests. Under favorable conditions it is capable of increasing to enormous numbers, and its caterpillars may completely defoliate the shade and park trees of a community. Excepting conifers, it attacks almost every variety of tree, and especially poplar, soft maple, elm, alder, birch, and willow. It is most destructive in cities. The caterpillars are given to migration, and the cocoons made by them may be located in almost any place that offers some measure of shelter. It is not abundant every year, being in the meantime kept in check by natural agencies, principally parasitic insects.

Signs of infestation.—From September until the following spring, conspicuous, glistening white, frothy-looking egg masses (fig. 24, *h*) may be observed, mostly low down on the trunk of the tree or on the

[19] *Hemerocampa leucostigma* S. & A.

main limbs. In the spring and summer, leaves partly or entirely eaten by the caterpillars are in evidence. These caterpillars when full grown are more than an inch in length, with red head, three long black plumes at the extremities of the body, and four yellow, brush-like tufts with two red spots behind them on the back (fig. 24, *a*). Cocoons and egg masses (fig. 24, *i*, *k*) occur on the bark of the trunk,

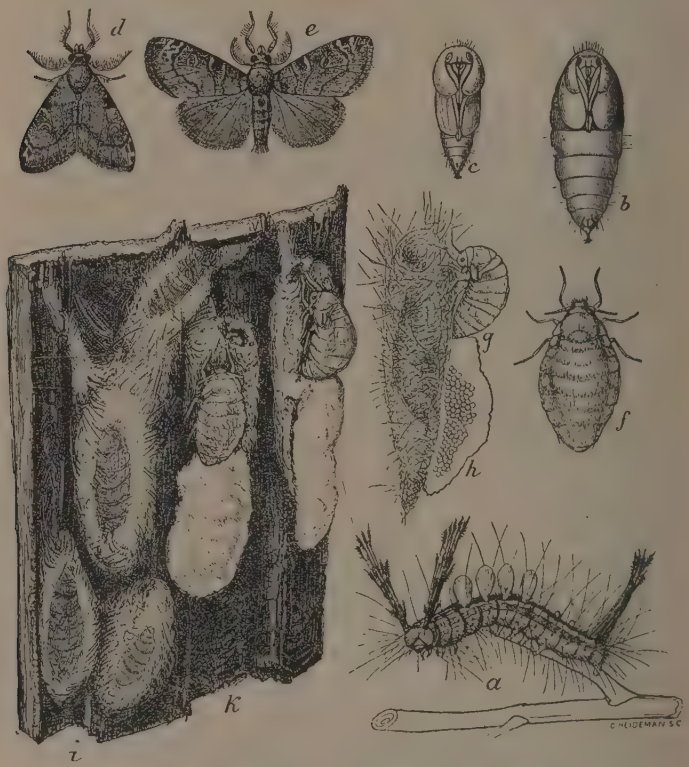

FIG. 24.—White-marked tussock moth: *a*, Larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs. All slightly enlarged (Howard.)

branches, and occasional leaves in localities where more than one generation is produced annually.

Seasonal history and habits.—From the overwintered eggs the caterpillars hatch in April and May and immediately begin to skeletonize the leaves, later eating holes through them, and finally devouring all but the main veins. Often they may be observed swinging from the tree on a silken thread, and, when caught by wind or passing objects, are transported to other trees. They remain as caterpillars from a month to five weeks, shedding the skin five times in

the course of their growth. When nearly full grown they are great travelers, especially from defoliated trees. When full grown the caterpillars spin delicate grayish cocoons of silk, mixed with hairs from their bodies, and within these cocoons they transform to pupæ (fig. 24, *b*, *c*) and, about two weeks later, these change into moths (fig. 24, *d*, *e*, *f*) of which the females are wingless. Mating and egg laying take place soon afterwards. Three generations of the insect are produced annually in Washington, D. C.; two or only one north of that city.

Remedies.—Destroy the eggs in the winter either by hand picking or scraping them off and burning, or by spraying or dabbing with creosote oil, mixed with turpentine to keep it liquid in winter. As soon as injury by the caterpillars is noticed, spray infested foliage with lead arsenate (p. 11). Hand picking or any simple device will do for treatment of the eggs. For spraying purposes a spray pump is necessary, and the size of the equipment will vary with the amount of work to be done. A barrel pump mounted on a horse-drawn cart with one or two 50 to 100 foot leads of garden hose and a 10-foot bamboo rod with a spray nozzle at the end will do for a small town. Cities will find advantage in horse or motor-drawn power spray pumps. The catalogues of reliable spray-pump manufacturers, giving detailed information, are procurable in most seed, pump, or hardware stores and should be consulted.

Essentials of successful control.—Thoroughness, concerted community action, and cooperation are essential for success. Leave as few surviving eggs or caterpillars as possible. Treatment of a tree here and there, now and then, protects no trees, not even those treated. All or most trees must be treated the same season, whether this be done by citizens individually or as a community organization. The trees attacked are usually large. Where spraying must be resorted to, the requisite apparatus is too expensive for the average individual, and can be bought (or hired) and operated only cooperatively, either through local governments or other civic organizations.

LOCUST LEAF-MINER.[20]

Evidence of work and seriousness.—About the time the locust leaves become full grown they are often observed to turn brown, as if fire scorched. Entire trees and groves of locust may assume this appearance. But aside from marring their appearance the injury to the trees is generally less real than apparent. No later than the following spring the trees are sure to put out a fresh, healthy set of leaves, as if nothing had happened.

[20] *Chalepus dorsalis* Thunb.

Cause of injury.—The locust leaves turn brown mainly because the green tissue within them is being hollowed out—"mined," we call it—by the flattened grubs (fig. 25, *b*) of this beetle; while the blister-like effect on them is produced by the surface feeding pits made by their parents. The parents of these grubs are about one-fourth inch long; they are flattened, orange-red beetles (fig. 25, *a*) with an area along the middle of the back, the head, appendages, and underside black, and the wing covers deeply pitted. This is the stage in which the winter is passed. In the spring, about May, in the District of Columbia, they appear on the leaves, feed, and begin laying eggs in batches of from 3 to 5. From these the grubs hatch and immediately penetrate to the inside of the leaf which they hollow out. On attaining full growth these grubs change to pupæ (fig. 25, *c*) which, in turn, change to adults that come out. These also feed on the leaves and thus help to complete their destruction. There is apparently but one generation produced annually in the latitude of the District of Columbia.

FIG. 25.—Locust leaf-miner: *a*, Beetle; *b*, larva; *c*, pupa. Five times natural size. (Chittenden.)

Remedy.—It is only specially prized trees that are worth treating, and on these an application of lead arsenate (p. 11) as soon as the leaves appear early in the season will kill the grubs as they issue from the eggs and before they penetrate the leaf epidermis, and thus the injury will be stopped.

GREEN-STRIPED MAPLE WORM.[21]

How injurious.—Some years the green-striped maple worm is a troublesome insect on maple trees, especially silver and swamp maples. In the absence of these, however, it has been found to feed on and defoliate other trees. It is capable of completely denuding the foliage twice or even three times during the same season, not only of entire trees but of entire rows and groves of them. Aside from disfiguring the trees for the time being, the defoliation also weakens them.

[21] *Anisota rubicunda* Fab.

The insect and its habits.—When full grown this maple worm is a smooth caterpillar (fig. 26, *d*, *e*) about 2 inches long, pale yellowish green in color, striped lengthwise with dark green, and having a pair of long black horns just back of the head and a number of black pegs along the sides and at its hind end. These caterpillars enter the ground, there changing to pupæ (fig. 26), *f*), from which the moths issue in about two weeks. The moth is a woolly-bodied, pink-shaded,

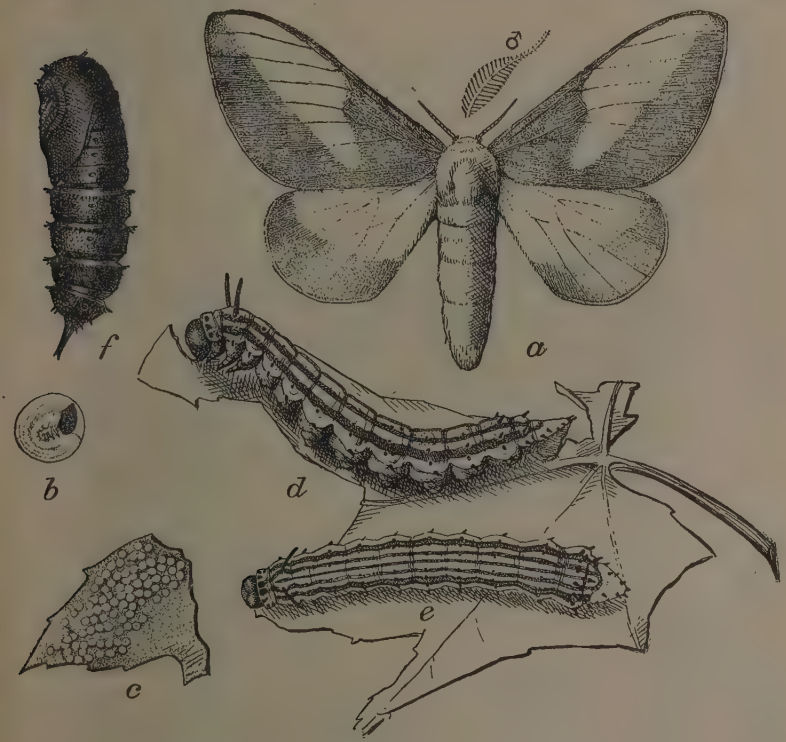

FIG. 26.—The green-striped maple worm in all its forms: *a*, Female moth and antenna of male moth; *b*, egg showing embryo within; *c*, portion of egg mass; *d*, full-grown larva from side; *e*, same from back; *f*, pupa. Enlarged. (Howard and Chittenden.)

pale yellow insect with a wing spread of about 2 inches (fig. 26, *a*). After mating the female lays on the underside of leaves about 150 eggs (fig. 26, *b*, *c*), from which the caterpillars hatch in about 10 days. The insect overwinters in the pupa state in the ground and the first generation of moths issues from them in May or June, depending on the locality, which also determines whether two or three crops of the caterpillars are produced annually. The green-striped maple worm is a native of North America, and this accounts for the periodicity of its abundance. In the intervals between outbreaks it is kept in check by its natural enemies, including birds and parasitic insects. It is

more abundant in the Middle West than in the East, although it is more or less generally distributed east of the 100th meridian.

Remedies.—On specially prized smaller plants some relief from this pest may be obtained by hand picking and destroying the caterpillars. Sizable trees should be sprayed with lead arsenate (p. 11) as soon as the caterpillars appear, to protect them from defoliation. In case of maple groves or suitably located individual trees it has

FIG. 27.—Cluster of full grown walnut caterpillars, showing peculiar poses, long hairs, and clustering habit. (Photograph by Cramer, Washington, D. C., Sept. 27, 1919.)

been found possible to protect them from a repetition of defoliation by digging around them a trench about a foot deep, with the outer wall sloping under, and destroying the caterpillars and pupæ that collect in them.

WALNUT CATERPILLAR.[22]

How injurious.—When there are enough of them, these caterpillars (fig. 27) strip walnut trees bare of leaves. Other trees also, especially butternut and hickory, are likely to suffer the same fate.

[22] *Datana integerrima* G. & R.

Successive defoliation in many instances kills the trees. The walnut caterpillar is more abundant and therefore more destructive some years than others.

How recognized.—When this insect is present pieces of leaves begin to disappear in late summer and early fall, eaten by the gregariously feeding caterpillars, which when full grown are black, covered with dirty gray hairs, and nearly 2 inches in length. When disturbed caterpillars rear at head and tail ends (fig. 27) in an unusual manner. On the trunk and larger branches of infested trees large clusters of caterpillars or their cast skins may be observed.

The insect and its habits.—On maturity the caterpillars crawl down the trunk of the tree an inch or two into the ground and there transform into chrysalids. In this shape they overwinter, remaining in the ground until the following July, when the moths issue from them and lay their whitish eggs in clusters of 75 to 100 on the underside of the leaves selected as food for the caterpillars that hatch from them. The habit of feeding and molting gregariously is a characteristic of this insect.

FIG. 28.—Caterpillar of cottonwood dagger moth. (Riley.)

Remedies.—Collect and destroy the clustered caterpillars feeding on twigs or molting on the trunk and branches. Failing this, and if the facilities are at hand, spray infested trees with lead arsenate (p. 11).

COTTONWOOD DAGGER MOTH.[23]

How injurious.—In prairie regions the caterpillar of the cottonwood dagger moth is a serious enemy of cottonwood and willow trees, which it often strips of foliage. As these trees are important in these regions for purposes of timber and shelter, this defoliation is a serious matter.

The insect and its habits.—The caterpillar (fig. 28) is densely covered with long, soft, drooping, yellow hairs, bears five rather long, stiff tufts of black hairs along the back, and when at rest it lies curled up on the underside of a leaf. When full grown it retires to some cranny where a silken cocoon, intermixed with its hairs, is spun and within it the change to chrysalis takes place.

[23] *Apatela populi* Riley.

In this form it overwinters and the following spring the pale gray moth emerges from it. The moths are night flyers and lay their eggs on the host plant, one in a place. Two cycles are completed in the course of the year in the latitude of Nebraska.

Remedy.—Spray infested trees with lead arsenate (p. 11).

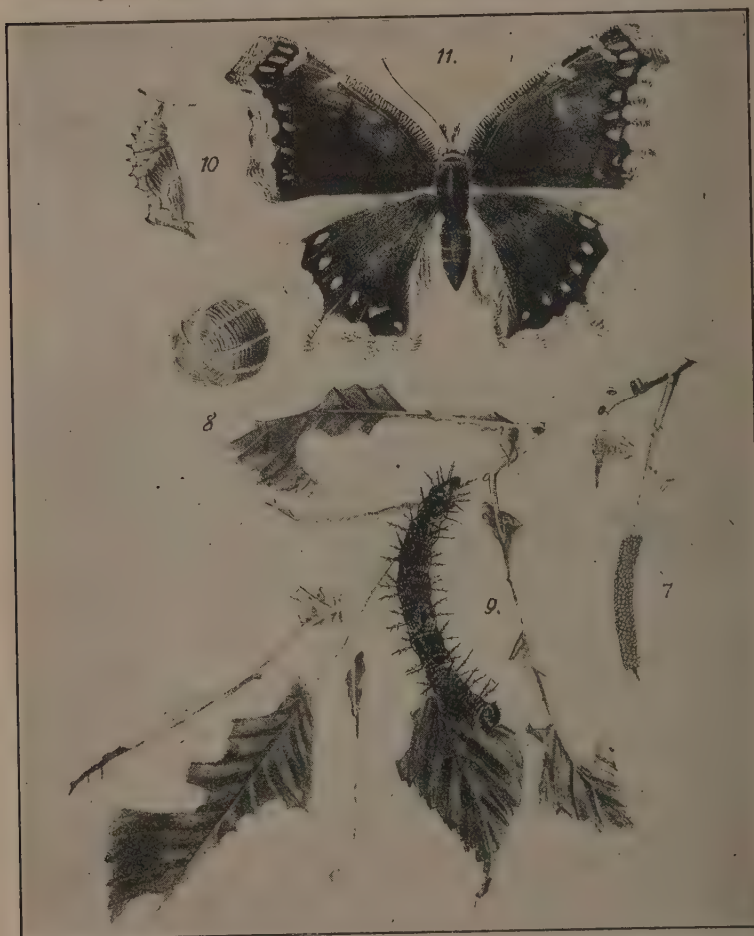

FIG. 29.—Spiny elm caterpillar: 7, Cluster of eggs on leaf stem; 8, one egg, much enlarged; 9, caterpillar feeding; 10, chrysalis hanging from leaf stem; 11, butterfly with spread wings. Egg cluster and caterpillar on elm twig showing characteristic appearance after feeding by the caterpillars. (Felt.)

SPINY ELM CATERPILLAR.[24]

How injurious.—The spiny elm caterpillar feeds on elm, willow, poplar, and hackberry leaves. The amount of injury depends on the

[24] *Euvanessa antiopa* L.

number of caterpillars present, but when abundant these are known to defoliate entire branches and trees. In our prairie regions, where trees are so scarce and precious, the injury to willows and poplars is most serious.

Appearance and habits.—If parts of leaves are missing or entire branches or trees are bare and stocked with black, red-marked, spiny caterpillars (fig. 29, *9*), about 2 inches long, feeding in groups, it is safe to conclude that this insect is the one responsible for the damage. On maturing the caterpillars change to strange looking sea-shell shaped chrysalids (fig. 29, *10*) which may be found suspended from a limb and fastened to it by the small end. After a few weeks the beautiful butterfly, known as the "mourning cloak" (fig. 29, *11*), the first butterfly to appear in the open in early spring, issues and, after mating, lays a batch of from 300 to 400 eggs (fig. 29, *7*, *8*) in a ring about the twig of the food plant. From one to three generations are

FIG. 30.—A hackberry butterfly, *Chlorippe celtis: a*, Eggs; *b*, larva, dorsal view; *c*, *d*, chrysalis, dorsal and lateral views; *e*, imago, male, dotted line showing form of female. (Riley.)

produced annually. The insect overwinters in the adult stage, the butterflies hiding under rocks and bark scales for protection.

Remedies.—Spray with lead arsenate (p. 11) as soon as signs of injury are observed. In some cases the twigs with clustered caterpillars may be cut off and the caterpillars destroyed by crushing, burning, or dipping in kerosene.

HACKBERRY BUTTERFLIES.[25]

How injurious.—The caterpillars of these butterflies feed on hackberry leaves wherever these trees grow and often greatly mar their appearance. As the hackberry is extensively grown as a shade tree

[25] *Chlorippe celtis* Bdv. and *C. clyton* Bdv.

in the Middle West, the injury of these insects assumes lively importance.

Appearance and habits.—Attention is drawn to the insect by hackberry leaves which show signs of being eaten away, and green caterpillars with pale spots and lines along the back and projections on head and rear (fig. 30, *b*) are found on the underside of leaves. The caterpillars change to chrysalids (fig. 30, *c*, *d*) in folded leaves and later to russet-gray, brown-spotted buterflies (fig. 30, *e*), which, after mating, lay their eggs singly (in one case, fig. 30, *a*) or in batches of 300 to 500. Two generations are produced annually, the second-stage caterpillars of the last generation falling to the ground with the leaves they are on and passing the winter there.

FIG. 31.—Streaked cottonwood leaf-beetle (*Melasoma scripta*), showing variation in markings. (Riley.)

Remedies.—The leaves may be raked up and burned in the fall or the infested trees sprayed with lead arsenate (p. 11) while the caterpillars are feeding.

COTTONWOOD, POPLAR, AND WILLOW LEAF-BEETLES.[26]

How injurious.—Poplar, cottonwood, and willow leaf-beetles are particularly injurious because their adults as well as young or larvæ derive their nourishment from eating the leaves of these trees, and, as they produce from three to five generations annually, they are capable of keeping the trees in a constant state of defoliation. They are most prevalent in the Northern States, are occasionally seriously injurious, especially to basket willow in the East, and are an almost constant drain on the health of these trees in the Middle West, where tree life is so scarce and precious that injury to it is intolerable.

How recognized.—Infestation is indicated by leaves of these trees bitten part way through in places and entirely through in others early in the season, and entirely consumed later by spotted, soft-bodied, short, stoutish grubs and spotted or striped, half-inch long, hard-shelled beetles (fig. 31), mostly on the underside of leaves where also batches of yellow or reddish eggs standing on end and pupæ are to be found. The young when disturbed emit a milky fluid.

Habits.—The overwintering beetles appear in the spring as soon as growth starts on these trees and promptly begin eating this growth. After feeding awhile they lay clusters of eggs from which the soft-

[26] *Melasoma scripta* Fab., *M. lapponica* L., *M. tremulae* Fab., and others.

bodied grubs hatch and begin eating away the underside of the leaf. When after several molts they are full grown, they partly cast the last skin and pupate in it fastened to the leaf. "Hangers" they are called in some sections of the country, where the beetles issuing from them are known as "hard shells." During the growing season the generations overlap, owing to more rapid development of some and slower growth of others, so that all stages, from egg to adult, may be found at the same time.

Remedy.—Spray with lead arsenate (p. 11), especially as soon as growth starts. Direct the spray against the underside of the leaves and for smooth leaves add soap (p. 14) so that the spray will stick to the leaves.

LARGE ELM AND WILLOW SAWFLY.[27]

How injurious.—More commonly in the Middle West, and locally in the East, the large elm and willow sawfly has been observed completely defoliating willow and elm trees and groves, and occasionally poplar and other trees. As stated in connection with other defoliating insects occurring in the Middle West, such outbreaks are pathetic in view of the solicitude with which trees are regarded there and the disappointment entailed when they are found undergoing despoliation.

How recognized.—Occasionally the tops of these trees look as if overrun by fire from the girdling of the bark of the twigs by the adult sawfly (fig. 32, *b*). More often, however, their leaves are found blistered by eggs or larvæ in pockets (fig. 32, *a*) or eaten by cylindrical, coiled, yellowish-white worms (fig. 32, *e*, *e*) with a black line down the middle of the back.

Habits.—The caterpillar-like insects that eat the leaves attain full growth about July or August and descend to the base of the tree where they spin a tough, coarse, silken cocoon (fig. 32, *f*) among the débris or just below the surface of the ground and overwinter there. The following spring they change to pupæ (fig. 32, *g*, *h*) and the adults, rather large, flylike insects, with four clear wings (fig. 32, *i*), appear about May, mate, and the females make slits in the fleshy part of the leaves and thrust their eggs (fig. 32, *c*) into these pockets and from these the young worms (fig. 32, *d*) come out to feed soon after hatching.

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[27] *Cimbex americana* Leach.

Remedies.—Winter burning the rubbish and breaking up the ground at the base of infested trees should destroy many of the insects. Where practicable, hand picking of worms or infested leaves early in the spring is a great help. Finally, lead arsenate (p. 11) is always a reliable stand-by against these insects.

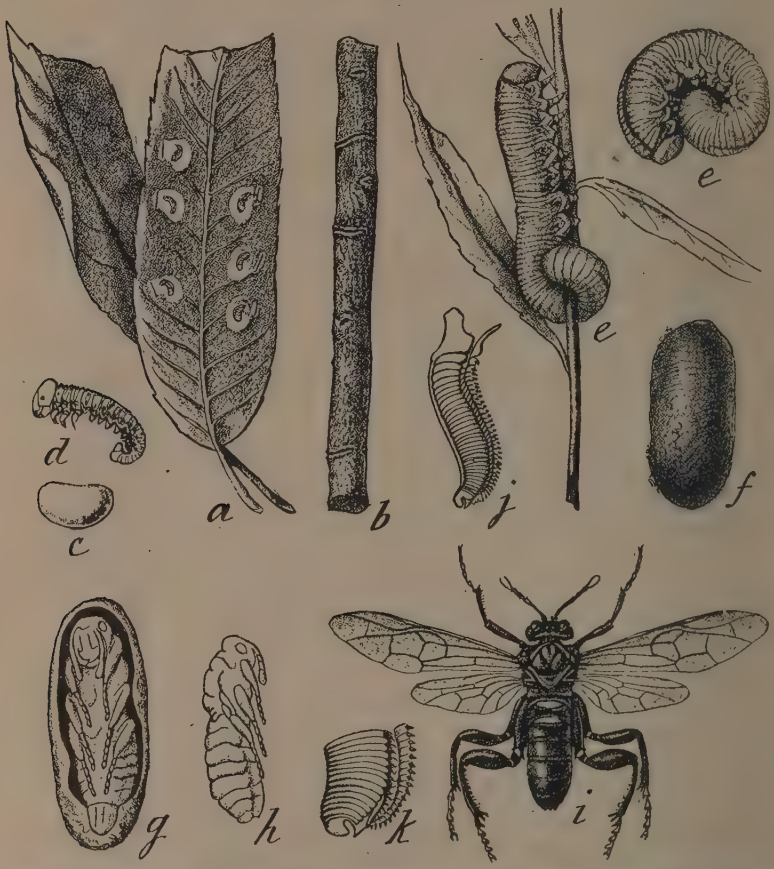

FIG. 32.—Large elm and willow sawfly; *a*, Willow leaves showing location of eggs; *b*, twig showing incisions made by adult; *c*, egg; *d*, newly-hatched larva; *e*, *e*, mature larvæ; *f*, cocoon; *g*, open cocoon showing pupa; *h*, pupa, side view; *i*, mature sawfly; *j*, *k*, saw of female; *c*, *d*, *j*, *k*, much enlarged, the rest less enlarged. (Riley.)

BARK, WOOD, AND TWIG BORING INSECTS.

GENERAL.

Boring insects secure their nourishment either by extracting it from chips of bark and wood that they bite off and swallow as they bur-

row or by feeding on the sap, depending on whether they feed in the dead wood or in the sapwood. Their injury to shade trees is along two directions: (1) When their burrows do not kill the tree or limb, they admit, on the body of the boring insect or in the moisture that penetrates their excavations, diseases which rot and ultimately disable or kill it; (2) when their burrows in that life-giving layer located between the bark and wood extend around the limb or tree, the circulation of sap between roots and leaves is arrested and death ensues quickly. In the case of timber the burrows also reduce in grade the lumber cut from it or make it entirely worthless. Moreover, the work of these insects is hidden from view, so that too often it is discovered when it is too late to save the tree. For these several reasons the presence of borers in trees is particularly dangerous and must be guarded against most carefully.

Because they feed and live most of their lives out of sight they are beyond reach of the usual poison or contact insecticides. The use of certain preparations, like poisoned miscible oil or kerosene emulsion or carbon disulphid, as will be pointed out under the respective insects, is practicable in a few instances. In the majority of cases, however, the healthy trees can be saved only by opportune sacrificing of those that are badly infested, or, in some cases, by stimulating the growth and well-being of those just invaded by these insects. Protection of shade trees from boring insects rests, therefore, almost wholly on preventive measures. Trees well nourished, protected from all manner of injury, and otherwise well cared for are more nearly immune to attack by boring insects than those not so cared for. In a neighborhood, community, grove, or park where a majority of the individuals of a given borer are destroyed the remaining trees will successfully resist attack and be saved thereby.

SUGAR-MAPLE BORER.[28]

How injurious.—In some sections of the country, especially along roadsides in New York State, the sugar-maple borer is regarded as the most serious enemy of this tree. It attacks trees in full vigor, killing large limbs and entire trees. The serious damage is done by the grubs, especially when their burrows meet so as to girdle the tree or limb.

Signs of borer presence.—When the borer is present the trees show dead limbs here and there; ridges and dead spots appear on the bark (fig. 33, *1*, *1a*), or naked scars on the branches and trunk, especially near the base of the larger limbs, sometimes with oval holes three-eighths to five-eighths inch in diameter, and "sawdust" (fig. 33, *6*) at

[28] *Plagionotus speciosus* Say.

the base of the tree or in bark crevices; the foliage on a large limb suddenly wilts, dries up, and dies with sap and small masses of frass flowing from some point. Any one or a combination of several of these signs indicates the work of this borer.

FIG. 33.—Sugar-maple borer and work: *1*, Place where egg was laid; *1a*, another more than normally discolored and showing borings thrown out by borer; *2*, grub in September from egg laid the same season; *3*, grub nearly full grown; *4*, beetle; *5*, hole through which beetle escaped; *6*, borings packed in burrow. (Felt.)

Description, seasonal history, and habits of the insect.—The borer is a whitish grub (fig. 33, *2*) about one-half inch long with brownish mouth parts, located at the end of the burrow in the sapwood, or about 2 inches long and of similar shape and color in a larger burrow somewhat deeper in the wood (fig. 33, *3*). The parent insect is a beetle about 1 inch long, stout, shorthorned, black, brilliantly marked with yellow (fig. 33, *4*). It comes out between June and August through oval holes in the bark (fig. 33, *5*).

Remedies.—Dying trees or limbs should be cut down and burned before June, so as to kill the grubs in them before they have transformed into adults and emerged. Specially prized trees should be examined in the fall and spring for signs of the insect, and the borers killed either by cutting them out (in which case cut surfaces should be covered with creosote-tar mixture or good white-lead paint (see p. 14–15), or by forcing a flexible wire to the end of the burrow, or

by injecting carbon disulphid (p. 14) into the holes and promptly plugging them with clay, putty, or similar substance. Where facilities are at hand the trunk and larger branches of the trees may be sprayed in the late summer with poisoned kerosene emulsion (p. 12–13) or miscible oil (p. 12), which will reach and kill the borers that have just penetrated the bark. Care should be taken to avoid spraying the foliage, as this is injured by these solutions.

ELM BORER.[29]

Signs of attack.—Elm trees only are subject to injury by this borer. The leaves of tops or ends of branches of infested trees turn brown and fall in summer, after which tops and branches here and there die, as shown by their failure to leaf out in the spring, and in two or three years the entire tree is killed. Thorough search of the trunk and larger branches of dying trees discloses patches of dead, readily peeling bark with burrowing roundheaded grubs beneath it (fig. 34, *1*). This is the form of the insect that does the injury, and when the limb or tree is girdled by the burrows (fig. 34, *3*) its doom is sealed.

How destructive.—Trees growing in unfavorable environment, particularly in cities, are most subject to attack by this borer, and then apparently only when the trees have been previously weakened by some other agency. Hence it becomes epidemic only occasionally, but on such occasions it is apt to wipe out the trees on entire blocks of some communities.

Distribution.—The elm borer probably occurs generally throughout the northeastern United States.

Description and seasonal history.—The parent insect is a gray, long-horned beetle (fig. 34, *4*), about one-half inch long and marked with red lines and black spots. Its flying period is between May and August. At that time the eggs are laid singly or in groups on the bark, where they hatch into tiny, footless grubs which promptly tunnel through it to the cambium layer. Here they excavate continuously wider cavities to accommodate them as they grow. These tunnels, when they reach around the tree or limb, girdle and kill. The full-grown grub (fig. 34, *1a*) is white, a little over an inch in length, thickest in front, but the head is only about half as wide as the segment immediately behind it. It is not definitely known how long the insect remains in the grub stage, but on reaching full growth it cuts out a cell beneath the bark and pupates in it, looking very much like a mummified beetle (fig. 34, *2*). In the spring, about May, these pupæ change to adult beetles which cut round holes in the bark and come out.

[29] *Saperda tridentata* Oliv.

Prevention of attack.—Once a tree is badly attacked nothing can save it and the axe is the best remedy. If this is applied during the winter or early spring, before the beetles begin to emerge, to all trees or infested branches of a community, and the wood is promptly burned, many of the beetles will be destroyed and the rest of the

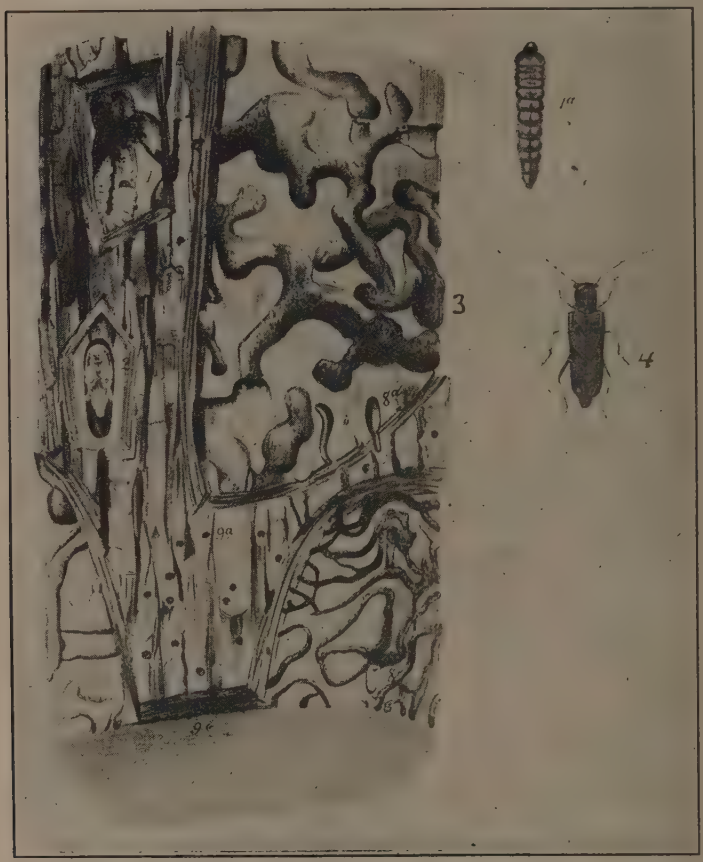

FIG. 34.—Elm borer and work: *1*, Grub within its burrow; *1a*, grub extended; *2*, pupa within its cell just under the bark; *3*, burrows of the grub exposed by removal of the bark; *4*, adult beetle. (Felt.)

trees saved. As indicated under "How destructive," removal or prevention of the agencies causing the primary weakening of the trees will go far toward preventing the beetles from inflicting the final fatal blow. This preventive work can best be called scientific arboriculture, and involves proper nourishment of the tree and its protection from injury.

LINDEN BORER.[30]

How injurious.—This insect apparently attacks only linden, but on this it is common and occasionally quite injurious. It is more or less generally distributed over the eastern United States.

How recognized.—Toward the end of summer tips are found killed and the green bark of growing shoots, leaf stems, and larger veins on the underside of leaves are eaten. This is the work of the beetles and is quite noticeable when the insect is abundant. Burrows made by a slender grub occur under the bark and deep in the wood (fig. 35, *11*, *16*) of the trunk nearer the ground, in exposed roots, and in lower limbs.

Habits of the insect.—The beetles (fig. 35, *15*), which are long-horned with six black spots on the middle of the back, issuing out of holes (fig. 35, *12*) in the bark, begin to appear in May, and after

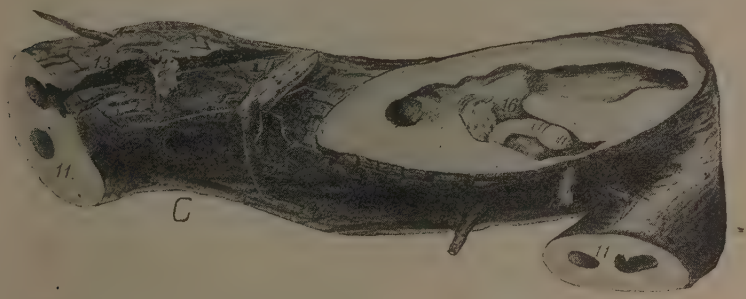

FIG. 35.—Linden borer and work: *11*, Burrows in cross section; *12*, circular exit hole of the beetle; *13*, wound made by borer; *14*, frass thrown out by larva; *15*, beetle; *16*, grub in the gallery under the bark which was cut away. (Felt.)

feeding awhile the females make with their jaws slight incisions in the bark and lay two or three eggs in each. One female lays about 90 eggs. The grubs (fig. 35, *16*) that hatch from these make the burrows mentioned above and, after an undetermined length of time, change to pupæ and then to beetles which leave the tree through holes in the bark throughout the summer.

Remedies.—On valuable trees the injury may be checked by digging out the borers. Probing with wire, injections of carbon disulphid (p. 14), and spraying with poisoned miscible-oil solution (p. 13) in the late summer are other serviceable means of killing this borer. Heavily infested and badly damaged trees are best cut and burned during the winter.

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[30] *Saperda vestita* Say.

ASPEN BORER.[31]

Character of damage.—The aspen borer is generally quite destructive to poplar trees and particularly so to aspen and cottonwood throughout the United States, especially in the Middle and Western States. Malformation of the trees, death of limbs and often the entire plant, and riddling of the main trunk with large holes which cause the tree to break off in the wind, are the usual results of the attack.

FIG. 36.—Aspen borer: Side and top views of beetle. Enlarged. (Hofer.)

External evidence of infestation.—In June and July irregular scars occur on the main trunk, especially around the crotch of branches, from which sap exudes and fibrous boring dust is thrust out. Later or older evidence of infestation is the enlargement of holes, extrusion of more or larger bits of frass, and often the death of limbs. The adults (fig. 36) are rarely seen because they feed on the young twigs and lay their eggs at night.

Description and habits.—The boring stage or larva (fig. 37) of the poplar borer is a yellowish, cylindrical grub which can be distinguished from all other insects boring in poplar by the presence of numerous fine, short, hard points on a plate immediately back of the head. It hatches from an egg laid in a scar on the bark by a grayish cylindrical beetle (fig. 36) with numerous brown spots over the body. The eggs are laid during the period from May to July, the young larvæ mining during the first year beneath the bark, and during the succeeding two years deep in the wood.

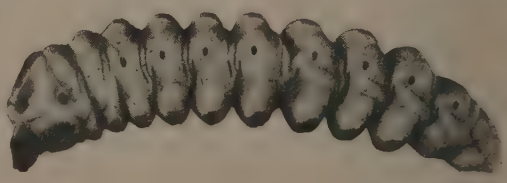

FIG. 37.—Aspen borer: Grub, much enlarged. (Hofer.)

Remedies.—For shade trees and small plantations or groves spraying of infested trunks during the late summer months with poisoned

[31] *Saperda calcarata* Say.

kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12–13) is recommended for killing the very young larvæ in the outer bark. On valuable trees some measure of relief may also be obtained by painting the eggs with creosote or carbolineum or by digging out and killing the young borers in early fall as they begin to tunnel their way into the wood. Heavily infested and badly damaged trees should be removed and burned or exposed to drying during the winter.

For a full account of the aspen borer see Farmers' Bulletin 1154 which will be sent on request.

BRONZE BIRCH BORER.[22]

Character and extent of injury. — During the past 20 years or so the birch trees of many city and private parks have died. As the top branches die first, the vitality of the trees gradually deteriorates and finally, one or two years later, the entire tree succumbs. This condition is usually due to the work of the bronze birch borer.

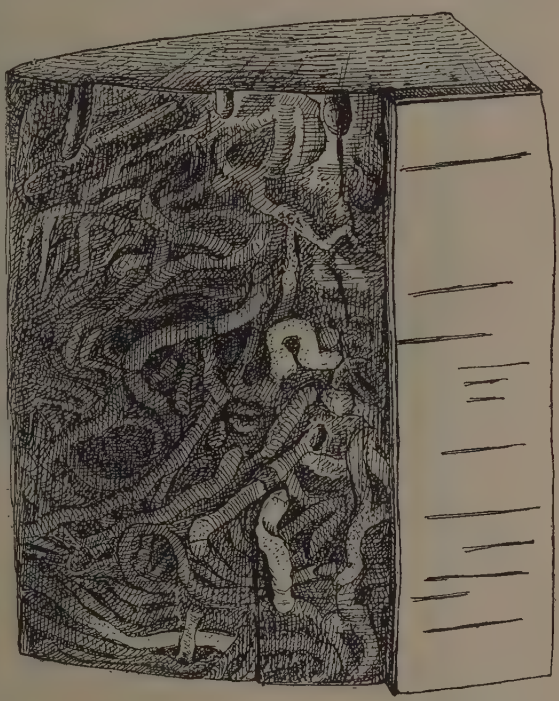

FIG. 38.—Work of bronze birch borer on trunk of white birch; bark removed to show larval galleries. Somewhat reduced. (Chittenden.)

Evidence of infestation.—The following are signs that the trees are infested: (1) Characteristic reddish or rusty brown spots or discoloration on the white bark of the trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows (fig. 38) in the bark of the wood; (2) ridges (fig. 39) in the bark on the branches which often develop over the burrows of the insect; (3) dying tops.

[22] *Agrilus anxius* Gory.

Seasonal history and habits.—The borer itself (fig. 40, *c*), i. e., the stage of the insect mainly responsible for the damage, is a slender, flattened, footless, creamy white grub, about three-fourths inch long when full grown, which transforms to a small, slender, olive-bronze, winged beetle (fig. 40, *a*) nearly one-half inch in length. This beetle emerges from the trees in May or early June, depending on the location and season, and the female deposits her eggs in crevices on rough surfaces of the bark, several together. These eggs hatch into tiny grubs which burrow their way through the bark, underneath which they tunnel a zigzag course in the bark and sapwood until they are full grown. In the autumn they excavate a chamber in the wood or outer bark and here spend the winter. About April or May the following spring they transform to pupæ, and these into the adults which gnaw their way out, leaving peculiar oval holes in the bark. Their life cycle is thus completed within a year. The beetle attacks birch, poplar, and aspen trees wherever they grow in the United States, being particularly destructive to imported birch in parks and lawns in the Northern States and attacking from slender branches to trunks of trees over 25 years old.

FIG. 39.—Work of bronze birch borer on limb of white birch. Somewhat reduced. (Chittenden.)

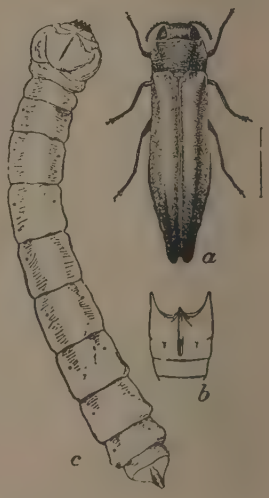

FIG. 40.—Bronze birch borer: *a*, Female beetle; *b*, first abdominal segments of male from below; *c*, larva from above. All enlarged about 3½ times; line at side of beetle shows natural length. (Chittenden.)

Prevention of damage, and control.—Badly damaged trees are not only past saving but are a menace to the trees of the neighborhood still free from attack; therefore trees showing dead tops and other evidences of infestation should be cut down and burned during autumn or winter and *not later than May 1.* A tree cut here and there will not check the ravages of

borers. This is a neighborhood or community problem, and to insure that the work is thoroughly done and in good season it must be enforced either by community ordinance or by aroused public sentiment and understanding.

THE PARANDRA BORER.[33]

How injurious.—Although primarily breeding in utility timber, like telephone and telegraph poles, and other structural wood in contact with the ground or in moist situations, this insect is frequently found in the eastern half of the country seriously injuring all kinds of mature shade trees. This injury is at the base, and in windstorms trunks and branches thus weakened break off easily. This insect probably accounts for a greater percentage of destroyed bases of shade trees than any other.

Character of work and habits of the insect.—The adult, a rather large brown beetle, flies during the month following the blossoming of the chestnut, laying large numbers of eggs deep in the heartwood wherever this is exposed. In this wood the grubs live as such for three or four years before changing to pupæ. They feed gregariously, completely honeycombing the wood and packing the mines with granular frass. The oval pupal cell is constructed in the wood, plugged behind with a wad of fibrous frass. Pupation takes place about a month before the adults emerge.

A small wound near the base or in the larger branches of living trees offers a place of entrance for the young grubs which, penetrating the heartwood, continue to feed until nothing remains but a shell of sapwood. Under certain conditions the adults do not emerge but mate and lay eggs in the same cavity in which they are working. Often the wound where they gained entrance heals over and shows no sign of their presence.

Remedies.—As it is very difficult or frequently impossible to locate points on the tree where this insect is working, remedial measures must be directed toward prevention of the injury. All scars, fresh wounds, or injuries exposing the wood should be painted (p. 14–15) or so treated that no decay can start and that they quickly heal. Old cavities should be thoroughly cleaned and filled with concrete, care being taken that all wood showing any trace of grub-made mines is removed.

TWO-LINED CHESTNUT AND OAK BORER.[34]

How injurious.—The sudden death of sickly and healthy chestnut and oak trees is most often traceable to injury by the two-lined chestnut and oak borer, as this is their most serious insect enemy. As high as 75 per cent of these trees have been killed off by it in some

[33] *Parandra brunnea* Fab. [34] *Agrilus bilineatus* Weber.

areas. In sickly trees the insect is very generally found associated with the shoe-string root fungus, or previous defoliation, and it unquestionably hastens the death of such trees. When weak trees are scarce and the beetles are numerous they may attack perfectly healthy trees and kill them.

Habits and appearance.—The beetles are on the wing in early summer, when they mate and lay eggs, preferably in deep cracks on the bark of the main trunk and branches. Each egg hatches into a flat, bigheaded, milky or yellowish white grub (fig. 41, *c*) which burrows through the bark and, by the time it is full-grown, by fall, it has excavated a burrow up to 3 feet long obliquely and across the grain in the inner bark and outer wood. It spends the winter in a chamber in the outer bark. Late the following spring it changes here to a pupa (fig. 41, *d*) and about two weeks later transforms to the adult, which is a dull or brownish black beetle (fig. 41, *a*) one-fourth to two-thirds inch long with two yellowish lines along the back, which burrows its way out of the tree and begins life in the open as described above. A number of such burrows (fig. 42), side by side around the trunk, girdle the tree and sever the vessels which carry food and moisture between roots and top, and the tree dies in consequence.

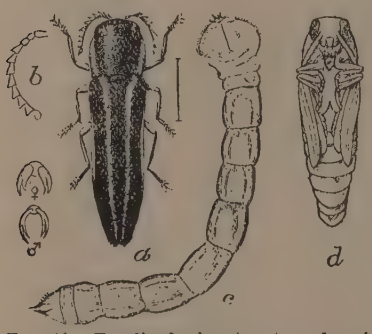

FIG. 41.—Two-lined chestnut and oak borer: *a*, Adult beetle; *b*, antenna of same; ♀, claws of posterior tarsi of female; ♂, same of male; *c*, larva; *d*, pupa. *a*, *b*, *c*, and *d*, Enlarged; *b*, ♂, and ♀, more enlarged. (Chittenden.)

Remedy (applicable only to specially prized, individual, slightly infested trees).—Spray the trunks during fall with poisoned kerosene emulsion (p. 12–13).

Prevention.—In the grove or forest prevention is the only practical means of control. This consists of the following measures calculated to eliminate the beetle's favorite breeding quarters (bark on freshly felled or dying trees and cordwood): Remove and promptly burn, during the fall, winter, or early spring, the bark (the wood may be utilized for any suitable or desired purpose) of all heavily infested, injured, weak, dying, and dead chestnut and oak trees and limbs over as wide an area about the trees to be protected as possible. Thoroughly done, this will kill the grubs in these trees, eliminate the borer's favorite breeding places, and reduce the numbers of the beetles to such an extent that those remaining will be incapable of effecting serious injury. In most cases extension of the area of control operations can be achieved only through cooperative or joint action of adjoining owners, and this must be secured for successful results.

Beetle brood trees left in the area will tend to nullify haphazard control work.

LOCUST BORER.[35]

Character and extent of injury.—The locust borer is the most destructive insect of black or yellow locust in some localities. Per-

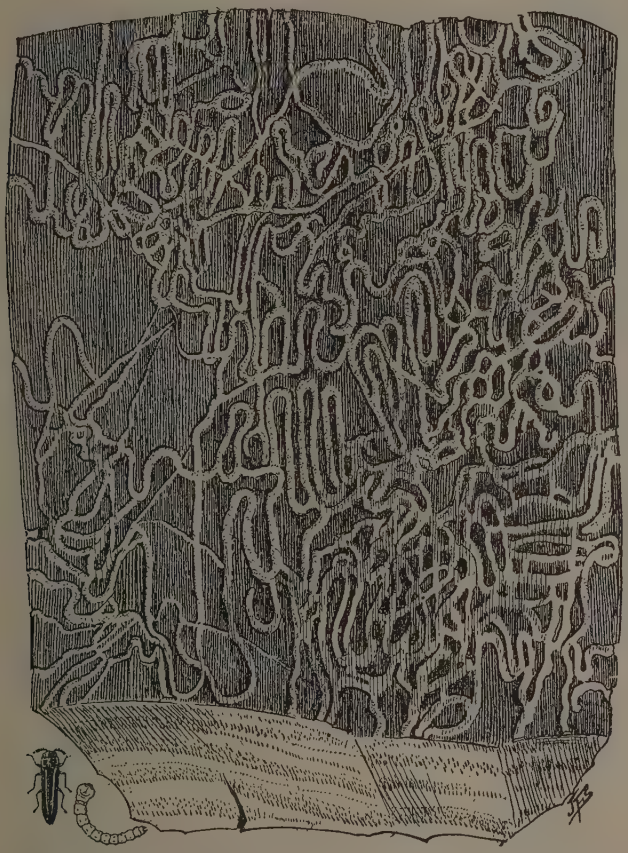

FIG. 42.—Work of two-lined chestnut and oak borer. Section of wood from main trunk of a dead chestnut, showing the larval mines on the outer surface after removal of bark. Beetle and grub at left lower corner. (Burke.)

fectly healthy trees are attacked. The wounds it makes in the bark and sapwood stunt their growth. If the attack is severe or continuous for a number of years, the trees, particularly young saplings and branches of larger trees, are killed and their wood is made worthless by the wormholes.

[35] *Cyllene robiniae* Forst.

Evidence of infestation.—In April and May brownish boring dust and wet spots are to be seen on the bark of the trunks and branches, and as the season advances wet spots and yellowish boring dust mixed with liquids are present in increasing quantity. Leaf buds fail to open, the foliage is dwarfed or faded and sickly, and branches and small trees break down. The frequent occurrence of the adults in the period from August to October, particularly on goldenrod flowers, indicates the presence of the insect in injurious numbers.

FIG. 43.—Section of trunk of locust tree, dying from injury by the locust borer. Shows burrows of borer in bark and wood; also the larva at *a*, and the beetle at *b*. (Webb.)

Description and habits.—The locust borer is a whitish, elongate, roundheaded grub (fig. 43, *a*). It hatches from an egg laid by a black, longhorned beetle (fig. 43, *b*) with yellow, zigzag stripes. The eggs are laid in crevices of the bark during the period from August to October and the young borers that hatch from them excavate individual cells in the outer layers of the inner, living bark, where they overwinter. In the spring they bore into the wood, where they change to pupæ during July and August and to beetles during August and September, whereupon the beetles bore exit holes and come out to mate and resume the life cycle. This beetle is a lover of and works in the sunlight, therefore shaded trunks and branches are not subject to its attack—a fact which, if borne in mind in connection with the care of locust plantations, will result in the saving of trees. (See Bulletin 787, United States Department of Agriculture.)

Remedy.—For shade trees and small plantations or groves, spray infested trees in the spring, when these trees begin to show green, with poisoned kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12, 13). This will kill the young borers in the bark.

Control.—Cut locust trees for posts, etc., during the dormant season, and peel and promptly burn the bark and branches to destroy the borers in the bark. In May and June (not later than the falling of the locust flowers) cut and burn all badly infested trees.

Prevention.—In localities where it is still absent, guard against introduction of the borer in posts or other products having the bark on. Regularly each year locate and destroy entirely or remove the bark from infested trees. Secure cooperation of neighbors in the work, so far as possible. Finally, allow all the undergrowth possible and keep growing trees untrimmed so that they will be well shaded when the beetles fly. The beetles, being sun loving, will not lay eggs on shaded trees.

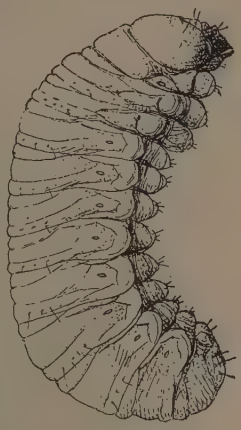

FIG. 44.—Grub of the mottled willow and poplar borer. Enlarged. (Chittenden.)

FIG. 45.—Poplar branch showing work of larva and punctures made by beetle of mottled willow and poplar borer (near bottom at right); also beetles. Natural size. (Chittenden.)

MOTTLED WILLOW AND POPLAR BORER.[36]

How injurious.—This is a most serious enemy of willow and poplar trees, the limbs and trunks of which it tunnels until they die or break in the wind. It found its way into this country a number of years ago and has since established itself in practically all the Northern States.

How recognized.—Dead or dying limbs, swellings, and dead patches of bark often cracked open on limbs or trunk, fading foliage, and "sawdust" and oozing sap at points of attack are signs of infestation. Fresh punctures made by the beetles while feeding on the younger shoots are also in evidence. Injured twigs, when split open, disclose burrows, mostly along the middle, and within each is a fleshy, white, footless grub (fig. 44) about one-half inch long when full grown.

Habit and appearance.—The grub is usually full grown about June or July, pupates, and turns to the adult, which is a rather stocky, dark colored snout-beetle (fig. 45) about three-eighths inch long, with spots and rear third of the wing covers pinkish white. For a week or two after emerging the beetles feed on the young bark and then the females begin to gouge out cavities in the bark of 2 to 4 year old growth and

[36] *Cryptorhynchus lapathi* L.

lay their eggs in them. The grubs hatching from these penetrate the bark and spend the winter directly under it. The following spring they resume feeding and keep it up until full grown, whereupon they bore into the wood, through it to the pith, and make a 3 to 4 inch gallery along that, filling it with wood fiber and pupating at one end of it. Thus the life cycle, although completed within a twelvemonth, extends from one calendar year into the next.

Remedies.—Cut out and burn all infested wood before May or June, thus preventing the grubs from reaching maturity and propagating. It appears possible also to control the insect by thoroughly coating the bark in July with lead arsenate (p. 11) or by painting trees with kerosene emulsion (p. 12, 13) in April or thereabouts.

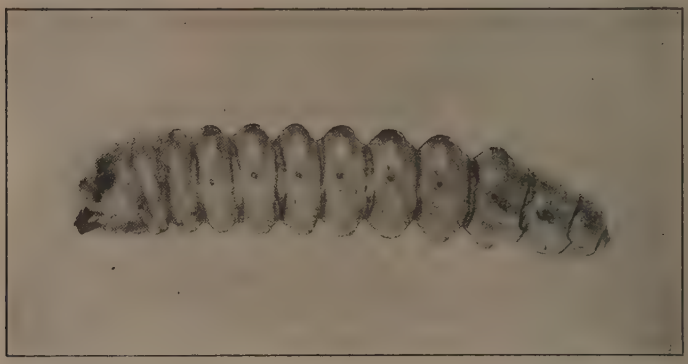

FIG. 46.—The cottonwood borer: Larva, side view. Enlarged. (Milliken.)

COTTONWOOD BORER.[37]

Destructiveness.—In the Middle West the cottonwood borer is very destructive to poplar or cottonwood and willow trees in all stages of growth. The mines of the borer, made at the base of the stem, often girdle the tree, causing its death or so reducing the strength of the wood that it is broken off by the wind.

Evidence of infestation.—Broken-off trees, sickly tops, and collections of shredded boring dust on the surface of the ground beneath the trees indicate the presence of the borers. On removal of the bark at the surface of the ground borer mines are disclosed.

Description and habits.—The cottonwood borer is a yellowish, elongate, cylindrical grub (fig. 46). It hatches from an egg laid by a large, black and white mottled, longhorned beetle (fig. 47). The eggs are laid during July and August in small punctures made in the bark at or just below the surface of the ground, and the borers

[37] *Plectrodera scalator* Fab.

hatching from them excavate individual mines, first beneath the bark and later deep into the wood, throwing out shredded borings as they work along. Two years of feeding in the tree pass before the borer matures and transforms to a beetle.

FIG. 47.—The cottonwood borer: Male beetle. More than twice natural size. (Milliken.)

Remedies.—In the case of shade and otherwise valuable trees the borer may be profitably killed either by being dug out while young or by injection of carbon disulphid (p. 14) into the hole showing fresh sap and boring dust, this hole being then promptly plugged with putty, clay, or similar substance. It seems as though the young borers might also be killed by spraying the infested trunk with poisoned kerosene emulsion (p. 12, 13) or miscible oil (p. 12, 13).

Prevention.—A wire screen, up to half an inch mesh, wrapped around the base of the tree so that it reaches about a foot above ground and several inches into the ground, which fits snugly at the top and is an inch or two away from the bark the rest of the way, will prevent the beetles from laying their eggs in it.

LEOPARD MOTH.[38]

Recognition of work.—The death or dying of limbs on otherwise healthy shade trees in cities along the Atlantic seaboard from eastern Massachusetts to southern New Jersey and in the Hudson River Val-

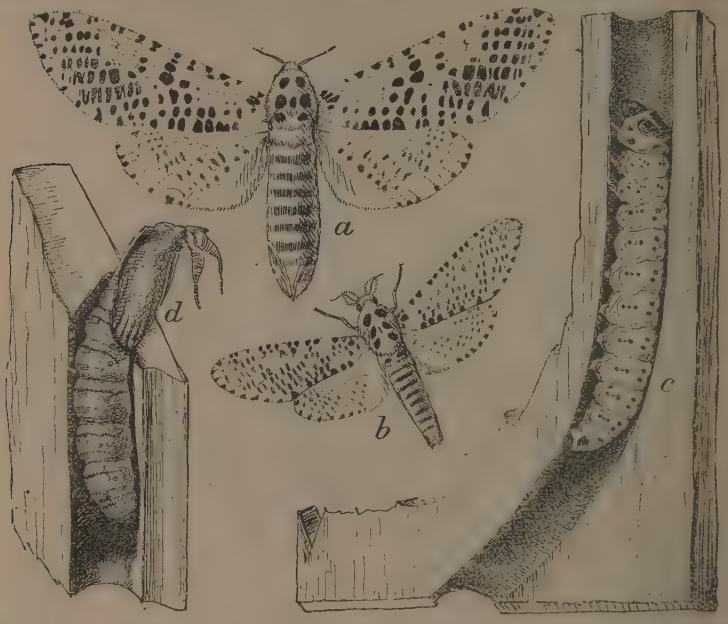

FIG. 48.—The leopard moth: *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Howard and Chittenden.)

ley is in many cases traceable to the destructive work of the caterpillars of the leopard moth. In cases of severe attack, especially on young trees, growth is checked and, when the trunk is girdled, death follows. In the region of its occurrence the leopard moth has proved to be a most serious menace to shade trees.

Habitats and seasonal history.—The leopard moth was introduced from Europe about 40 years ago, but fortunately its spread has been very slow. The caterpillar of this moth is a wood-boring insect, and feeds on the living wood in branches and trunks of deciduous trees. Evergreens are not attacked. From the time it hatches out of the egg, about two years pass before the caterpillar (fig. 48, *c*) stops

[38] *Zeuzera pyrina* Fab.

growing and changes to a chrysalis within its burrow (fig. 48, *d*). When it becomes mature, which happens during the period between May and September, the pupa or chrysalis forces its way partly out of the burrow (fig. 48, *d*), its skin splits open, and the leopardlike, spotted white moth (fig. 48, *a*, *b*) come out of it. Immediately after mating the female begins egg laying. As many as 800 eggs were observed to have been laid by a single female. The eggs are laid singly and in groups of three or more in crevices of the rough bark, from which they hatch about 10 days later and the issuing larvæ begin to burrow their tunnels toward the heart of the wood, thus completing the two-year life cycle.

Methods of control.—No easy method of wholesale destruction of this insect is known at present. Badly infested trees and limbs should be cut and *burned promptly* lest the borers migrate from them to the healthy wood. Many young and highly prized trees, showing only a few burrows, have been saved from death and even further injury by killing the borers in them with carbon disulphid injected into the burrows (p. 14). A flexible wire in many cases can be employed to advantage for killing borers in their burrows by probing. Clean culture, prompt attention, and simultaneous community work are necessary for effective control. Farmers' Bulletin 708 contains full information on this insect.

CARPENTER WORM.[39]

How destructive.—Although it rarely kills trees, the large burrows up to one-half inch wide made by the carpenter worm in the very heart of trees produce serious deformities which render the trees unsightly. Oak, chestnut, maple, locust, and cottonwood are among the trees most likely to suffer from it.

Indication of presence.—Infestation is shown by the wilting of smaller twigs, strings of frass dangling from holes in the bark, the large gallery (fig. 49, *9*), and, when present, the inhabiting worm, which is a large, vivid, reddish-white caterpillar (fig. 49, *7*) up to nearly 3 inches in length, greenish beneath, with scattered, long, fine hairs on the body and with head shining black.

Seasonal history and habits.—It takes this insect about three years to complete its life round, which accounts for the presence of caterpillars in badly infested wood at all seasons of the year. In an oval cell made by the caterpillar at the outer end of the gallery just before completing growth, transformation to the chrysalis (fig. 49, *6*) takes place in May or June. After about two weeks' life as such the chrysalis wriggles partly out of the hole in the tree (fig. 49, *5*) and

[39] *Prionoxystus robiniae* Peck.

the adult moth (fig. 49, *4*) emerges from it. Soon after mating the female begins laying her eggs (fig. 49, *4a*), from 300 to 400 in number, a few in a place and preferably near wounds or scars. The hatching of the eggs and penetration of the resulting caterpillars (fig. 49, *8*) to the heartwood complete the life cycle to the point from which its description was begun.

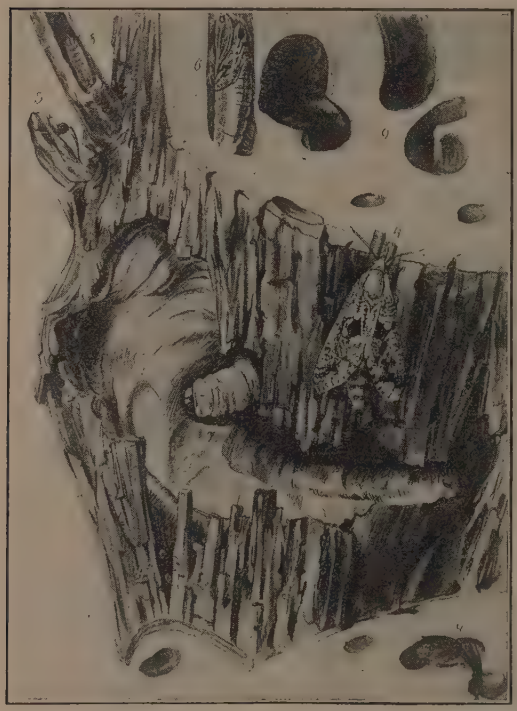

FIG. 49.—Carpenter worm and work: *4*, Female at rest on the bark; *4a*, dark colored eggs deposited loosely in the crevices; *5*, empty pupal case partly sticking out of the burrow; *6*, pupa within its cell; *7*, full grown caterpillar with its head protruding from the burrow; *8*, young caterpillar at work in a small twig; *9*, irregular burrows of full grown caterpillars. (Felt.)

Prevention.—Avoid wounding trees; dress wounds with tar or paint them (p. 14–15) after they are made.

Remedies.—Cut off during the winter and promptly burn all infested wood. Inject carbon disulphid (p. 14) into the wounds and promptly plug them with putty, grafting wax, or similar substance.

MAPLE AND OAK TWIG-PRUNER.[40]

Extent of injury.—While not a menace to the life of trees, the work of the maple and oak twig-pruner, which is often very abundant, tends to destroy the shape and thereby to mar the appearance of trees, besides littering with débris the ground beneath them.

Recognition of work.—During the summer and fall the ground beneath trees is found more or less strewn with small twigs, showing a clean cut at the larger end (fig. 50) with a burrow in the center plugged with wood shavings. Quantities of such twigs may also be hanging from the tree. Freshly fallen twigs, when split in two, disclose the hollowed-out interior and usually at some point within the

[40] *Elaphidion villosum* Fab.

burrow the whitish grub (fig. 50, *a*) with brown jaws that did the damage.

Seasonal history and habits.—The grub above referred to passes the winter in the fallen twig and changes to a pupa early next spring, unless this change has taken place late in the fall, which happens not infrequently. A little later in the spring the pupæ change to adult beetles (fig. 50, *b*), which begin emergence from the wood about June and remain abroad all summer, laying their eggs in July in the smaller twigs of, preferably, oak, but also of maple and other trees. The eggs hatch into grubs, which tunnel and sever the twig.

Remedy.—As the fallen branches usually contain the destructive insect in one form or another, gathering and burning them before emergence is the most logical and the simplest means of controlling the pest.

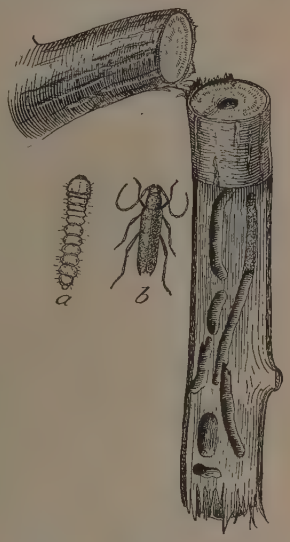

FIG. 50.—The maple and oak twig-pruner: *a*, Larva; *b*, adult; pruned twig and larval mines at right. (Webb.)

TWIG GIRDLERS.[41]

How injurious.—Trees are often found with numerous twigs lying on the ground beneath them or still hanging, dead. The larger ends of such twigs show evidence of having been cut off, and at some place in the burrow running the length of them the architect of the burrow may be found. Among shade and grove trees, hickory, persimmon, elm, poplar, sour gum, basswood, honey locust, dogwood in the East and South, and huisache, mesquite, and acacias in the Southwest, are subject to this injury. This is the work of beetles known as twig-girdlers, and may become so prevalent as to deform trees badly. Young hickory trees are frequently cut off near the ground. The hickory twig-girdler[42] in the East, the pecan twig-girdler[43] in the South, and the huisache girdler[44] in the Southwest, are the insects involved.

Character of work and habits of the insects.—In late summer or early fall these beetles appear and often feed on the thin bark before laying the eggs. The adult female girdles branches of the host tree by cutting a circular incision through the bark and deep into the wood. The twigs so girdled vary from ¼ to 1½ inches in diameter. In these twigs the eggs are deposited in a small scar gnawed through

[41] *Oncideres* spp.
[42] *Oncideres cingulata* Say.
[43] *O. texana* Horn.
[44] *O. putator* Thom.

the bark. These branches soon die and most of them fall to the ground. Until the middle of the following summer the larvae feed in the wood, loosely filling the mine with frass, though much of it may be expelled. The pupal cell is firmly walled with fibrous frass. One year is required to complete the development, though in more northern localities many of the larvae feed through the second year before pupating. A high mortality occurs in the larva stage, due to too many borers in the same twig or excessive drying of the branches.

Remedy.—Gather and burn twigs as fast as they fall.

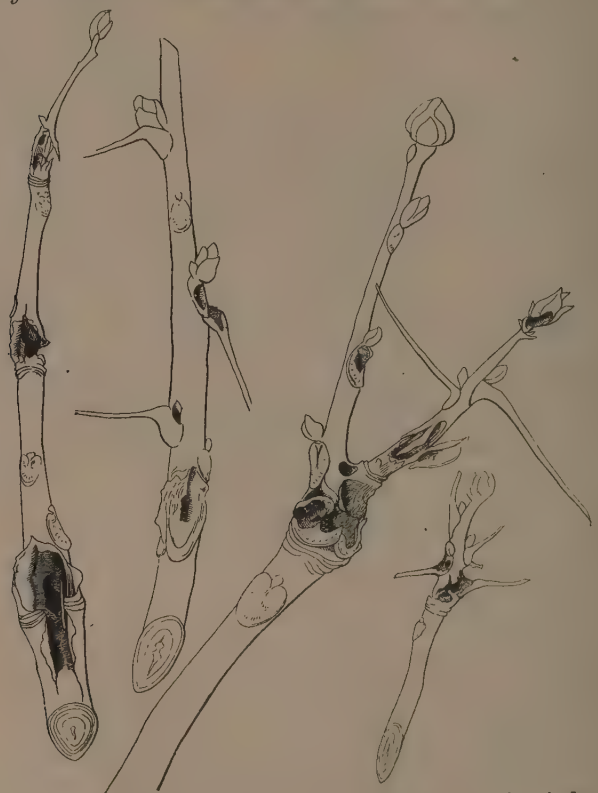

FIG. 51.—Injury by the hickory barkbeetle to the twigs, buds, and base of leaves. (Hopkins.)

HICKORY BARKBEETLE.[45]

How destructive.—For years the number of dead and dying hickory trees throughout this country has been increasing. In many instances the death of these trees has been traced to the work of the hickory barkbeetle. This beetle, then, constitutes a serious enemy of our hickory trees, which, unless prompt steps are taken, are in danger of being seriously depleted.

[45] *Scolytus quadrispinosus* Say.

Evidence of infestation.—The presence and work of the hickory barkbeetle are indicated in several ways: (1) Bases of twigs, buds, and fallen hickory leaves in the spring show signs of having been eaten by insects (fig. 51); (2) clear-cut, round holes occur in the bark; (3) in August and September the foliage of hickory is faded and dying; (4) the inner bark of hickory trees and the wood surface beneath it are engraved with peculiar centipede-shaped designs (fig. 52), consisting of a broader, central, straight, upright gallery with narrower burrows radiating like centipede legs from either side of it.

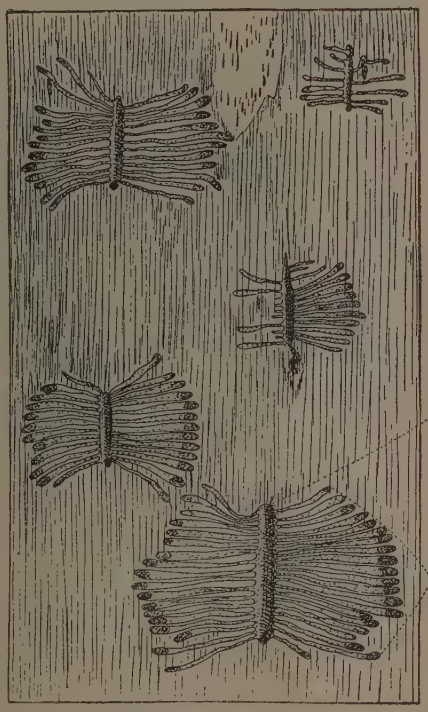

FIG. 52.—Work of the hickory barkbeetle on surface of wood beneath bark. *a*, Primary or egg gallery; *b*, larval mines. (Hopkins.)

History of seasonal activity.—About the time the pollen is falling from the tassels of healthy hickories the beetles mate and each pair starts the excavation of an upright gallery. In niches along the sides of these, eggs are laid which hatch into the grubs that tunnel out the "centipede legs." Until the larvæ are about half grown they feed in the inner layers of bark; later they tunnel into the middle and outer layers of it and pass the winter there. In the following spring they change to pupæ and then to adults, which emerge soon thereafter, thus completing the life cycle in one year. Retarded development of some individuals and accelerated development of others often complicate the situation so that most often all stages of the insect may be found in the same tree at the same time. Each barkbeetle brood gallery cuts that much of the sap flow between root and top, and when these galleries connect up completely around the trunk the tree is girdled and doomed to inevitable death.

Natural checks.—Like all native insects, the hickory barkbeetle is subject to attack in the mature and immature stages by a variety of parasitic and predatory insect and other enemies. By means of the sap flow a vigorous hickory tree is also capable of stubbornly re-

sisting attack. The attack can not be successful, therefore, unless the vitality of the tree is low at the time of attack or unless the beetles are sufficiently numerous to overwhelm a healthy tree. An abundance of sickly, dying, or felled hickory trees in the near vicinity provides favorable conditions for the production of an excess of beetles.

Control.—The evident means of checking the ravages of this pest is to keep the beetles down below a number sufficient to attack vigorous trees successfully. This can be accomplished (1) by putting into practice the very important principle of forestry of prompt, systematic removal from the area and disposal of all hickory trees which show signs of decline, and (2) by cutting and utilizing, for firewood or otherwise, the badly infested trees in the area.

FIG. 53.—Sycamore lace-bug: Adult, greatly enlarged. (Wade.)

SAP-SUCKING INSECTS.

GENERAL.

The feeding of sap-sucking insects on deciduous shade trees is not manifested by visible holes in leaf or bark, but usually by discolored or wilting foliage and generally by the sickly and often black, dirty appearance of the trees. As these insects do not feed on plant tissue but on plant sap, which they secure from the inner tissues by thrusting their beaks through the outer layers, they can not be destroyed by poisoning the foliage of the trees on which they live but must be hit directly by substances which kill on coming in contact with their bodies and which, therefore, are known as contact insecticides.

SYCAMORE LACE-BUG.[46]

How injurious.—By no means can the sycamore lace-bug be called a tree-killing insect, but great numbers of it not only discolor the foliage of the sycamore, its only host tree, but also cause premature falling of the leaves, thus rendering the tree unsightly and littering the ground beneath it. It may be found on sycamore, especially *Platanus occidentalis*, wherever it grows in the United States.

How recognized.—The sycamore leaves are off color in irregular spots or entirely and the underside is inhabited by colonies of queer, rather slow-moving bugs with prettily marked, lace-like horizontal wings (fig. 53), or their offspring with larger or smaller wing pads.

[46] *Corythuca ciliata* Say.

Habits.—The winter is passed in the adult stage hidden in crevices on the bark of the host tree. As growth starts in the spring the over-wintered individuals move over to the foliage and, after feeding for a week or two and mating, the females lay groups of eggs on the underside of the leaf. These hatch in about two weeks into tiny bugs, which differ from the adults only in lacking wings, and promptly begin feeding. They cast their skin or molt as they grow, doing so five times before maturity is reached. Two or more generations a year are produced, depending on the length and condition of the season, and varying therefore with the latitude and climate of the locality.

Remedy.—When the lace-bug is excessively abundant and other conditions permit, it has been found possible to achieve satisfactory control by spraying the insects with soap solution (p. 14).

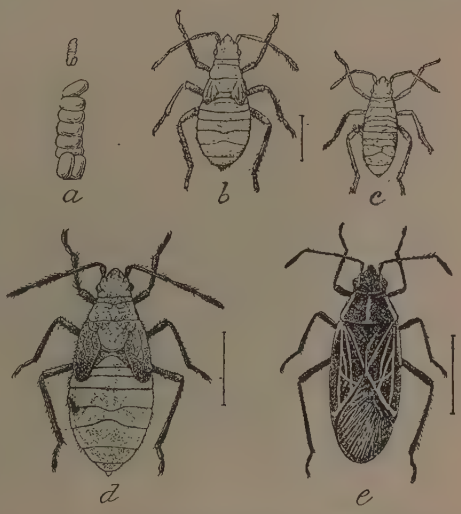

FIG. 54.—The boxelder plant-bug: *a*, Eggs enlarged, natural size above; *b*, *c*, *d*, different stages of immature bugs; *e*, adult. All enlarged; natural sizes indicated by hair lines. (*a–d*, Marlatt; *e*, Howard.)

BOXELDER PLANT-BUG.[47]

How injurious.—Although it feeds on plants only, and primarily on boxelder, this bug (fig. 54, *e*) is known mainly as a fall house pest owing to the fact that, if the infested tree is near enough, masses of the bugs in search of winter quarters are apt to invade dwellings and become a general nuisance there, besides alarming the unwitting householders. It first came to notice some 40 years ago in the far West, but has since spread pretty generally over the States west of the Mississippi River, and has recently been reported in States east of that river.

How recognized.—In late summer large numbers of bright red, wingless or red bordered, darker winged bugs may be seen sucking the sap from the leaves and tender growth of boxelder or, in the fall, masses of them wandering up and down the trunk of the tree and crawling up brick walls and into houses, cellars, and all sorts of cracks and crevices in search of hibernation quarters.

[47] *Leptocoris trivittatus* Say.

Habits.—The adults emerge from hibernation about the time box-elder buds open and lay their eggs (fig. 54, *a*), usually in crevices of the bark of this favorite host tree. The hatching young migrate to the foliage in great hordes, traveling up and down the trunk. After several molts (fig. 54, *b*, *c*, *d*) maturity is reached and by fall great streams of the bugs start on the march for winter shelter.

Remedies.—Spray trees as soon as the insects appear with soap solution (p. 14) or kerosene emulsion (p. 12–13). In the fall great masses of them can be destroyed by pouring hot water or kerosene on them or by sweeping them into a vessel containing kerosene.

SCALE INSECTS IN GENERAL.

Appearance and habits.—Scale insects are so called because of the scale that covers or constitutes the back of most of them. This covering may be horny, leathery, waxy, cottony, or mealy, and just as various in size, shape, and color. There are many species of scale insects; and, according to the consistency of their covering, they are roughly divided into *armored scales*, *soft* (leathery) *scales*, *cottony scales*, *mealybugs*, etc. Except for a few days after hatching, when they are naked, these insects are nearly always covered by the scale characteristic of the species to which they belong. The number of generations annually, date of hatching, and other life-history habits vary with the species, season, and location. They are all plant feeders, some confining themselves to a single species of plant, while others occur on a great variety of plants. They occur on roots, main stems, branches, and twigs; some of them occur also on the leaves and fruit in summer. They feed on sap, which, by means of their slender, flexible, needlelike beaks, they suck up from within the plant tissues. They are, therefore, classified as sucking insects. Some of them produce more or less honeydew, which attracts ants, bees, wasps, etc., which eat it but do not harm the plants. Certain fungi growing on honeydew frequently give the affected plants a sooty appearance.

Natural control.—Like other insects, most scale insects are usually kept in check by a variety of natural agencies, especially parasitic and predacious insects. Under such conditions they do no permanent serious harm and require no remedial treatment. Quite often, however, some species become so numerous as to be very injurious, and make early treatment imperative if the life of the affected plant is to be saved or its value kept unimpaired.

Remedies.—Winter spraying with a contact insecticide (p. 11–14), done when the buds are dormant, is preferable for scale insects because (1) there is then no delicate foliage to injure and none to conceal the insects or to use up the spray; (2) dead and superfluous portions of the plant may and should then be removed, still further reducing the area to be sprayed and exposing the insects; (3) plants

are then dormant and can withstand stronger sprays without injury. Summer spraying, when imperative, is most effectively done when the young are at the height of hatching, i. e., crawling about in numbers.

OYSTER-SHELL SCALE.[48]

How injurious.—The oyster-shell scale lives and feeds on a great variety of shade trees, especially poplar, maple, birch, beech, and willow, besides hardy shrubs and certain fruit trees, all over this country, and though it occasionally kills an entire grown tree, it generally retards and stunts the infested growth and frequently causes the death of twigs and branches.

How recognized.—The bark of an infested branch is found more or less densely crusted with brown or grayish, rather long, somewhat bent scales (fig. 55), wider at one end than the other, and sloughing off more or less readily.

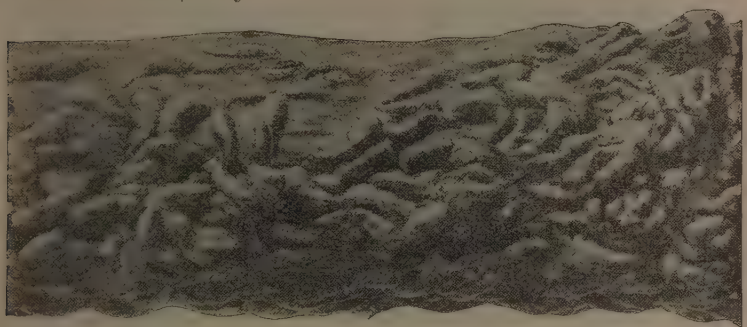

FIG. 55.—Oyster-shell scale on poplar. Much enlarged. (Quaintance and Sasscer.)

Habits and seasonal history.—Shortly after the apple blossoms fall the eggs of the oyster-shell scale, which overwinter beneath the female scale, hatch into minute, licelike insects which crawl about for three or four days, and after inserting the threadlike beak, which serves as an anchor as well as a food conduit, into the host, settle permanently on the bark. Thereafter the female never leaves the scale started by it when young, but ultimately lays its eggs and dies there.

Control.—Here and there an infestation by these scale-bugs is checked by minute, wasplike, parasitic insects that kill them. In most cases, however, spraying with lime-sulphur (p. 11–12) or a miscible oil (p. 12) must be resorted to for a prompt, effective remedy. The necessary preliminary work in preparation for spraying is indicated on pages 15–16.

SAN JOSE SCALE.[49]

How injurious.—For a series of years at the close of the last century the San Jose scale was the most dreaded insect pest of the

[48] *Lepidosaphes ulmi* L. [49] *Aspidiotus perniciosus* Comst.

horticulturist, for not only was it found exceedingly destructive, but few woody plants seemed immune to it. Since then time and intensive study have developed both insect enemies and remedial measures which have effectively curbed its inroads. Nevertheless it is still a serious pest at times here and there, limbs and whole trees being killed by it.

How recognized.—Ailing trees show the smooth bark roughened and covered with scurf (fig. 56, *a–c*) beneath which pouchlike, yellow insects (fig. 56, *c*) may be observed. The live wood under such bark is tinged with bright red and circles of the same color surround these insects on green growth, leaves, and, in the case of orchard trees, the fruit.

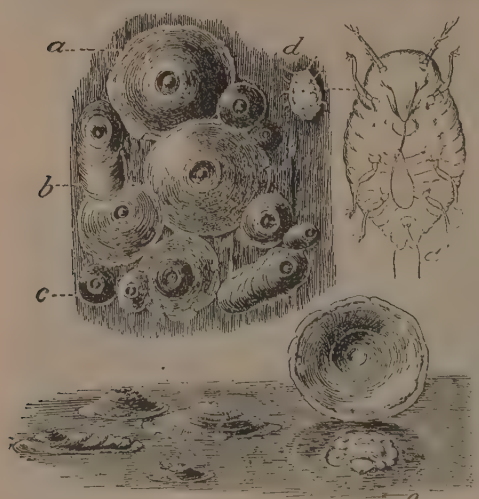

FIG. 56.—San Jose scale: *a*, Adult female scale; *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same highly magnified; *e*, scale removed showing body of female beneath. All much enlarged. (Quaintance.)

Habits.—Attached to the bark this scale insect hibernates in immature stages, resuming feeding and growth with the advent of spring. Maturity is reached and young (fig. 56, *d*, *d'*) are hatching in Washington about the middle of June. After crawling about for a day or two the tiny yellow louse settles down to feed and build the scale. From three to five generations are produced annually, varying with the latitude and climatic conditions.

Remedies.—The San Jose scale readily yields to treatment with miscible oils (p. 12) or with lime-sulphur (p. 11, 12) where their application is practicable. Even fish-oil soap solutions (p. 14) or kerosene emulsion (p. 12–13) give satisfactory results. In heavy infestations two treatments should initiate the work, one in the fall as soon as the leaves fall and the other in the spring just before the buds swell.

GLOOMY SCALE.[50]

How injurious.—The gloomy scale is a special enemy of soft-maple trees, which it often cripples or kills, though other maples may be infested by it. It is especially abundant in the South where it is eliminating the soft maple as a shade tree.

[50] *Chrysomphalus tenebricosus* Comst.

How recognized.—In appearance it is not unlike the San Jose scale (fig. 56) and the effect produced by it is much the same, except that the red color is absent from the area it infests and the scale is larger and coarser. Also white rings, places from which the scales have peeled off, are a characteristic appearance on old infested surfaces.

Habits.—In its habits this scale is very much like the San Jose scale, except that apparently only one generation is produced in Washington, D. C., and proportionately more farther south. It is a prolific breeder, however, and can incrust trees with its scales in a comparatively short time.

Remedy.—Winter applications of miscible-oil solution (p. 12) will keep it in check.

OBSCURE SCALE.[51]

How injurious.—Oak is the favorite and only host of the obscure scale, and young trees and branches may suffer severely from it or even be killed. This is particularly true of the southern half of the country.

How recognized.—This insect looks much like the San Jose scale. In addition, large whitish rings or circles, which are spots from which the scales have been rubbed off, are an evidence of infestation with this scale. The reddish discoloration characteristic of the San Jose scale is absent and the scale is even coarser than the gloomy scale.

Habits.—Very much like the preceding.

Remedy.—Winter applications of miscible-oil solution (p. 12).

PUBESCENT OAK KERMES.[52]

How injurious.—The pubescent oak Kermes can by no means be considered a tree-killing insect, although twigs here and there may be killed by it. The growth of badly infested trees, however, is severely checked, the tender growth particularly. This scale insect occurs on oaks only; white oak (*Quercus alba*) suffers most from it in the vicinity of Washington, D. C.; burr oak in Ohio and Indiana; and red, chestnut, and chinquapin oaks are other species on which it has been collected.

How recognized.—During the growing season leaves and green, soft wood are found crumpled up, and motionless, hairy, plump bodies resembling the background in color are attached to them. When mature, the insects become much more rounded and chestnut brown in color. Occasionally small, feltlike, white sacks may be found on the wood of branches. These are the male cocoons. To-

[51] *Chrysomphalus obscurus* Comst. [52] *Kermes pubescens* Bogue.

ward the end of the season leaves begin to die and clumps of them remain attached to the tree through most of the winter. During the winter masses of tiny, reddish, licelike insects may be found in cracks of the branches and twigs.

Habits.—The overwintering young desert their winter quarters about the time buds on the white oak begin to open and migrate to the new growth, where they settle and, inserting their beaks, begin to feed, usually on the midribs of leaves and the soft wood. Wherever one of them settles growth ceases, while the surrounding tissue, of the leaf blade, for instance, continues growing, thus producing the sagging effect. At maturity the body of the female becomes filled with eggs, which, in Washington, D. C., hatch early in July, the "lice" coming from them infesting further the year's growth. Two generations are produced during the year, the offspring of the second hatching late in the fall and migrating to the bark for hibernation.

Remedy.—Experiments made by the writer on several groups of large oak trees have shown that a water solution of miscible oil, 1–15, thoroughly applied at the time the buds begin to swell on the white oak in the spring, kills 85 to 90 per cent of the young insects without hurting the tree in any way. In the given case a high-power sprayer with a solid-stream nozzle was used. The cost of the spraying material averaged about 50 cents a tree. The labor in this particular instance was abundant and free so that no estimate of the cost could well be made. An average of 15 minutes was consumed by the crew to a tree, including transportation over the grounds and time required to fill the tank. For further details on this subject see pages 12 and 22 to 30.

TULIP-TREE SOFT SCALE.[53]

How injurious.—Branches of tulip trees may be so crowded with the tulip-tree soft scale that they sicken and die, greatly disfiguring the tree.

How recognized.—Sickly, blackened branches are found thickly beset on the underside with vivid gray to brown, prominently raised scales about one-fourth inch long and a little narrower. Toward fall the young may be observed crawling about and settling on the bark.

Habits.—The young pass the winter on the bark where, the following spring and summer, they feed and grow, producing young again toward fall, thus making only one generation a year in the latitude of Washington, D. C.

Remedy.—Miscible-oil solution (p. 12) has been found to be an effective remedy for this insect.

[53] *Toumeyella liriodendri* Gmel.

MAGNOLIA SOFT SCALE.[54]

The magnolia soft scale, as its name indicates, occurs primarily on magnolias, although occasionally on tulip trees. Its appearance, effects, and habits are similar to those of the species infesting the tulip and so also are the measures for its control.

TERRAPIN SCALE.[55]

How injurious.—Maple, especially sugar maple, and sycamore and poplar, among shade trees, are particularly subject to infestation by the terrapin scale, which occurs in several States west of the Mississippi River, and in all of those east of it. It is largely a twig scale.

How recognized.—Infested twigs show the drain from which they are suffering by their wilting and dying foliage. The twigs are more or less heavily incrusted with raised reddish scales (fig. 57) about one-sixteenth to one-eighth inch long, about half as much in diameter, and ridged along the edges. Green shoots and the large veins of leaves are beset with young, licelike insects from midsummer on. Honeydew and black sootlike growth occur on and beneath infested twigs.

FIG. 57.—Terrapin scale. Adult females on twig of peach. Enlarged about three times. (Sanders.)

Habits.—In a half-grown condition the insect passes the winter on the bark of twigs and branches of its host, resuming feeding and growth as soon as spring starts. Toward the end of May, in the latitude of Washington, D. C., they are full grown and the females are filled with eggs, the young beginning to hatch about the middle

[54] *Neolecanium cornuparvum* Thro.

[55] *Lecanium nigrofasciatum* Perg.

of June and continuing to hatch through most of the summer. Evidently only one generation is produced annually in the District of Columbia.

Remedies.—There is little doubt that kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12), applied in the early spring before the buds have opened, will effectively kill off most of the pest.

COTTONY MAPLE SCALE.[56]

How injurious.—The cottony maple scale attacks a great variety of trees and vines. Its food consists of sap obtained by sucking it from within the plant tissues. Occasionally the insect appears in great numbers and at such times is apt to injure shade and other trees materially.

FIG. 58.—Cottony maple scale. Females with cottony ball full of eggs. (Howard.)

Seasonal history and habits.—This scale insect, even when present in great numbers, remains unnoticed until about June, when, at about the latitude of Washington, D. C., it is rendered strikingly conspicuous by the large, white, cottony egg mass which appears at that time at the end of the body of the female insects (fig. 58). The eggs hatch in early summer, though sometimes this hatching extends into August, and the young settle upon the twigs and underside of leaves. In the fall the females migrate to the twigs, where they remain unchanged through the winter, rapidly swelling in the spring and forming the egg mass in early summer. Thus only one generation is produced annually.

Remedies.—Remedies are rarely necessary. Where occasion arises for their use, a spray of dilute (summer strength) kerosene emulsion (p. 12–13) during the hatching of the eggs (June and July) is certain to prove effective.

EUROPEAN ELM SCALE.[57]

History and damage.—The European elm scale, an immigrant from Europe in about 1884, lives on the elm and may occur wherever this tree is grown in the United States. As a rule it does not kill

[56] *Pulvinaria vitis* L.

[57] *Gossyparia spuria* Modeer.

the trees, but it is often so very injurious, especially to young stock, that, together with the injury caused by the elm leaf-beetle, another importation from Europe, attack by bark-borers, etc., is induced and the trees do not recover.

How it lives and looks.—This scale spends the winter in crevices of the bark on the trunk and larger branches as brown immature males and females embedded in white cottony matter (fig. 59). On the appearance of warm weather, in May at Washington, D. C., these forms begin to move about, molt, and mate, after which the females attach themselves permanently on limbs and trunk. The young—clear, lemon-yellow, lice-like insects—issue during June and July, settling temporarily on leaves alone or on leaves and twigs, depending on the smoothness of the latter. In August they return to the larger branches and trunk to settle for the winter, thus completing in Washington the seasonal life cycle.

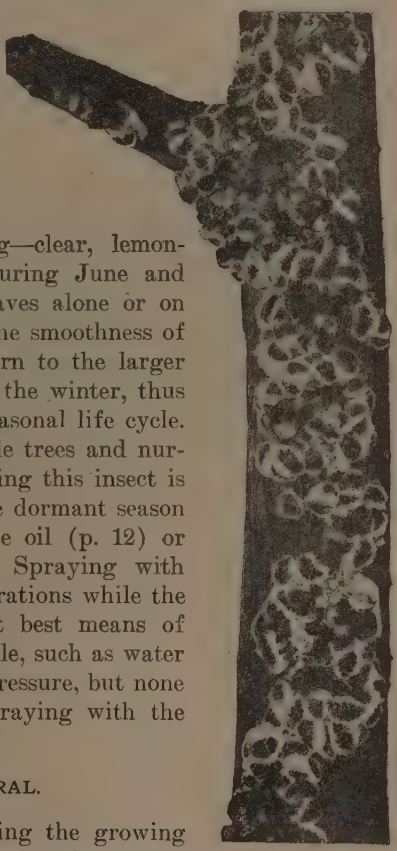

FIG. 59.—European elm scale: Mature females. (Photograph by Sanders.)

Remedies.—In the case of shade trees and nursery stock the best means of killing this insect is to spray infested trees during the dormant season with a water solution of miscible oil (p. 12) or kerosene emulsion (p. 12–13). Spraying with summer strengths of these preparations while the young are hatching is the next best means of control. Other means are available, such as water applied with a hose under high pressure, but none of them is as satisfactory as spraying with the solutions mentioned.

APHIDS IN GENERAL.

Evidence of infestation.—During the growing season aphids or plant-lice occur in winged and wingless form in greater or less numbers on branches, twigs, and leaves. They feed on the sap, which they suck up from within the tissues by means of their pointed beaks, hence are classed as sucking insects. Under favorable conditions aphids suddenly appear in great numbers, particularly in the spring. Their presence is indicated by an abundance of sticky "honeydew" on and under the infested plants, by the presence of ants which feed on the honeydew but do not harm

the plant, and by the curling and the abnormal falling of the leaves. When this honeydew is very copious, the black film which forms upon it gives the leaves and other portions of the plant a dirty appearance and clogs their breathing pores. Many aphids also produce various growths, called galls, on the tree parts they inhabit.

Control.—Notwithstanding their great numbers, aphids are usually incapable of doing permanent harm to an otherwise vigorous tree. They are never excessively abundant for long periods, being decimated by their numerous insect enemies, and a sharp change in the weather to hot and dry makes their disappearance as sudden as their appearance. Hence treatment, which involves labor and expense and requires an adequate spraying equipment, is in most cases safely dispensed with. When conditions warrant, however, it is possible and not difficult to check aphid injury artificially, as described under the several species. The strength of the solution used should be in proportion to the resistance of the plant to be sprayed; that is to say, the more delicate the plant the weaker the solution. Thoroughness and early application, before the leaves begin to curl, is indispensable to success. Often a forceful stream of water out of a hose directed against the aphids will dislodge and destroy them. Cooperation with neighbors in the purchase and operation of equipment, or in the employment of reliable and competent persons who make a specialty of the work, is desirable where feasible.

NORWAY MAPLE APHIS.[65]

How injurious.—This aphis frequently occurs in large colonies during much of the summer on the underside of Norway maple leaves, which are evidently its favored food. It is a copious producer of honeydew, which accumulates on the leaves and the pavement beneath them. Many of the leaves either develop brown blotches or fall off later, littering the ground and temporarily disfiguring the tree, besides seriously checking growth generally.

How recognized.—The leaves are off color, with honeydew, a sticky sweetish liquid, on them and on the ground below them, and many, mostly wingless, yellowish green, brown marked, licelike insects of various sizes with reddish eyes and long hairy antennæ are found on the underside of the leaves.

Habits.—Our knowledge of the habits of this insect, beyond what has been indicated above, is limited. Fortunately, what is known helps considerably in controlling the insect.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) mixed with soap and diluted in the usual manner will prove quite effective,

[65] *Periphyllus lyropictus* Kess.

and as little time as possible should be lost between the discovery of the insect and the application of the remedy. The spray solution should be directed especially at the underside of the leaves.

BOXELDER APHIS.[59]

How injurious.—This is an insect of the Middle West where the boxelder is its sole host. Its feeding stunts the young leaves, and its honeydew, together with dust and sooty fungus, soils the tree so that it looks most unattractive.

How recognized.—Numerous tiny, pale green, licelike insects are noted on the leaves and tender twigs, and there is a sootlike covering on the leaves and twigs or a sticky liquid on the leaves and on the ground beneath the tree. Drops of this liquid also hit persons beneath infested trees.

Habits.—The winter is passed in the form of eggs laid on boxelder bark. In the spring, as buds begin to push out, the eggs commence hatching and the emerging insects migrate to the new growth, where they forthwith insert their beaks and begin to feed. On reaching maturity they begin to produce living young, each "shelling out" as many as a hundred or more in the course of 20 days or so. Four or five generations thus follow one another in quick succession until about early June, when a generation of a quiescent, inactive form appears, gradually increasing in proportion to the others until August, when only occasional active individuals are to be found. The "dimorphs," as the resting insects are called, do not feed, but rest on the leaves throughout the summer, when the growth seems to take on a new lease on life. Early in September the dimorphs change to the normal, active form and produce another generation or two of living young. All of the individuals hitherto spoken of are females and most of them are wingless. The last generation of the season alone is composed of males and females, and the latter, after mating, deposit their eggs on the bark of twigs and branches, where they overwinter, thus completing the cycle.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) applied at the time new growth starts is a pretty sure and safe remedy.

TULIP-TREE APHIS.[60]

Appearance and injury.—The sole injury of the tulip-tree aphis consists in the abnormally heavy dropping of the leaves, but in a yard or on a street the littering of the ground is a serious objection. The falling tulip-tree foliage, on the other hand, usually indicates the presence of this insect in great numbers on the leaves. The insects

[59] *Periphyllus negundinis* Thos. [60] *Macrosiphum liriodendri* Mon.

have the characteristic appearance of aphids, the winged ones being reddish brown with a pale green abdomen, and there are a few pale reddish individuals scattered among them.

Remedy.—Forty per cent nicotine sulphate (p. 13) applied as soon as the insects are observed will control them.

WOOLLY MAPLE AND ALDER APHIS.[61]

How injurious.—While this insect can not be considered a serious enemy of the maple, which is the more important of its two hosts, owners of infested trees are greatly distressed by the masses of white cottony fluff they find covering the leaves of their favorite shade tree in the spring, and are insistent on knowing the nature of it and the remedy.

FIG. 60.—Colony of woolly maple and alder aphis on underside of maple leaf. (Pergande.)

How recognized.—The abundant, bluish white, cottony fluff on the underside of folded-over maple leaves (fig. 60), in the midst of which, from spring to midsummer, winged or wingless (immature) insects are found, is an indication of the presence of this aphis.

Habits.—The aphids in the white woolly masses which appear on the young maple leaves early in the spring come from eggs that were laid the previous fall in cracks and under loose bark on the trunk of the tree. As they reach maturity and acquire wings they migrate to alder, which may be quite a distance away. This may last until midsummer, when all have abandoned the maple. On the alder the migrants settle on the underside of leaves and produce living young, which move over to the bark of twigs, branches, or stems, and settle, feed, and grow there, several generations succeeding one another. Some of the last generation here produced fly back to the maple in the fall, there producing a generation of males and females, the latter laying the eggs with which the cycle was started. Those on the alder that did not migrate in the fall crawl down to the ground, hiding for the winter on the roots and in the leaves and débris at the bottom of the plant, and not coming out until the sap rises the following spring, whereupon they resume the usual activities of feeding and reproduction.

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[61] *Prociphilus tessellatus* Fitch.

Remedies.—Since it is not a dangerous insect and treatment of large trees is usually costly, it is not imperative to do anything. Under certain conditions there might be justification for either destroying or treating alders in the neighborhood, and the maple trees, of course, may be treated direct. Both kerosene emulsion (p. 12–13) and 40 per cent nicotine sulphate (p. 13) are efficient agencies for killing this pest.

FIG. 61.—Woolly beech aphis on underside of leaves.

BEECH-TREE BLIGHT APHIS[62] AND WOOLLY BEECH APHIS.[63]

How injurious.—While not a menace to the life of trees, the beech-tree blight aphis and woolly beech aphis frequently occur in such abundance as not only to mar the appearance of the trees but also to kill twigs and young trees. The woolly beech aphis (fig. 61) is found to be specially abundant on copper beech leaves.

How recognized.—The masses of bluish-white woolly aphids on the underside of the limbs are the beech-tree blight aphis and those on the underside of the leaves are the woolly beech aphis.

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[62] *Prociphilus imbricator* Fitch. [63] *Phyllaphis fagi* L.

Habits.—Nothing unusual is known as regards the habits of these insects, so that a reference to any of the other aphids discussed in this bulletin will give an adequate idea on this subject.

Remedies.—Kerosene emulsion (p. 12–13) or 40 per cent nicotine sulphate (p. 13), applied when the aphids are observed, will give necessary relief.

WOOLLY ELM BARK APHIS.[64]

How injurious.—The vitality of trees is not seriously affected by the woolly elm bark aphis but the knotting and gnarling of twigs and trunks (fig. 62) of young elm trees disfigure them. The white elm appears to be its favorite host tree.

FIG. 62.—Work of woolly elm bark aphis on large elms at Albuquerque, N. Mex. (Photograph by Whitesides, Dec. 13, 1919.)

How recognized.—When this insect is present and at work the trunk and branches show roughened knots with clusters of a white, woolly substance and licelike insects during the spring and summer.

Habits and remedies.—This insect spends its entire life on the elm bark so that treatment on this tree will effectively check its injurious activity. There should be no difficulty in controlling it with 40 per cent nicotine sulphate (p. 13), kerosene emulsion (p. 12–13), or a 5 to 7 per cent solution of a standard miscible oil (p. 12) applied to the bark, the latter in winter.

GALL-MAKING INSECTS AND MITES.

GENERAL.

Leaves and branches of many kinds of trees, particularly oak, maple, hickory, and hackberry, are subject to a great variety of peculiar growths called galls, most of which are made by insects or mites and which may become so numerous at times as to appear alarming. They vary much in shape, size, color, and structure, each being so characteristic of the kind of insect that makes and inhabits it as to afford a reliable guide to the specific identity of the architect in very many cases.

[64] *Eriosoma rileyi* Thos.

Rarely is a tree harmed by these galls sufficiently to menace its life or even good health. Likewise are they seldom numerous many years in succession, but while they last they do mar the appearance of otherwise healthy and beautiful trees, and their spectacular aspect tends to alarm the less informed tree owners and wardens.

Because of their evanescence and comparative harmlessness, treatment for gall insects is rarely imperative. Another deterrent factor in the undertaking of control measures against this sort of injury is the necessity of rather expensive spraying machinery for the work in many cases, and the cost of purchase or hire of this, as well as of its operation, added to the cost of the requisite insecticides, is apt to be rather excessive. It can only be justified where cost is no consideration, and even then, where the injury is not likely to receive general treatment in a neighborhood, the results of the operation are likely to be unsatisfactory on account of reinfestation from untreated near-by trees.

LEAF-STEM AND OTHER POPLAR GALL INSECTS.[65]

How injurious.—The vitality of trees infested with these aphids is never seriously affected. When the insects are abundant, the galls they make and their feeding frequently cause a heavy dropping of the foliage during the growing season, which, like the misshapen galls produced by some of them, is objectionable because it temporarily disfigures the tree and litters the ground.

How recognized.—The presence of these aphids is shown by heavy premature falling of the leaves, which bear rather prominent swellings on the midrib or leaf stem, the licelike insects lining the insides of them.

Habits.—Of the several species of these aphids known to make galls on poplar leaves, leaf stems, and twigs, the seasonal history of only the species here noted [65] has been worked out. This is somewhat complicated but rather interesting and is, briefly, as follows: By the time the galls are full grown in the fall, winged forms are developed in them and these migrate to the roots of cruciferous plants like cabbage, turnip, etc., where they breed until the following spring. At that time a generation of winged forms is again produced and these fly back to poplar where they give birth to wingless males and females on the bark. After mating the female lays one egg which hatches into the form known as stem mother. The young stem mother appears about the time the leaves begin to develop and migrates to and settles to feed on a stem of a leaf, which begins to swell and grow around her until she is completely enveloped by the

[65] *Pemphigus populi-transversus* Riley et spp.

gall. Within this gall she reaches maturity and gives birth to the numerous living lice that we find filling it in midsummer. The characteristic feature of the gall made by this species is that its mouth, which later serves as an outlet for its inhabitants, runs crosswise of the leaf stem. This seasonal history applies to the South where the study was made, and while in the main it doubtless applies also to the North there may be some seasonal differences.

FIG. 63.—The hickory phylloxera (*Phylloxera* sp.): Galls on pecan. (Gill.)

Remedies.—For reasons advanced in connection with other less injurious insects, circumstances are rarely such as to merit or justify control measures. In extreme cases, however, the application of remedial measures might be considered. Depending on conditions, control in such cases may be centered either on cruciferous plants or on poplar trees. In the latter, removing and burning of the infested leaves or dipping them in kerosene to kill the insects would greatly assist in reducing their numbers.

HICKORY GALL-INSECTS.[66]

Evidence of infestation.—In the spring, when the leaves and twigs are forming on the hickory, these are frequently more or less deformed by peculiar tumorlike growths of various shapes and sizes (fig. 63). These are caused either by gall-lice related to the grape phylloxera or by gall midges. When these galls occur in large numbers they disfigure the affected parts and attract attention, but this rarely affects the vitality of the tree materially. Their great variety—30 species of Phylloxeridae and 28 of Itonididae, beside 3 mites (Eriophyidae) are listed under hickory in the latest work on American gall insects—and their

[66] Families Phylloxeridae and Itonididae.

general distribution entail heavy infestation at some place in the country each season, with consequent frequent inquiry as to the cause and remedy, so that consideration of them here is made necessary, if for no other reason, to allay the prevailing fear of the consequence of their attack. The similarity of effect and economic relation invite joint consideration of all hickory gall insects.

Seasonal history and habits.

Phylloxeridae.—From early June of one year to early April of the next, or about 10 months of the year, is passed by these insects in the egg stage located in cracks and crevices, old galls, etc., on the hickory tree, particularly on the upper part of it. Coincident with the bursting of the buds in the spring these eggs begin to hatch, and the larvæ ultimately become the so-called stem mothers. These stem mothers settle on the young twigs, leaf stems, midribs, or forming nuts and each of them starts the formation of a gall with an inner cavity. In about 20 days from the time the gall is started the stem mothers deposit large numbers of eggs from which, in about 20 days, a generation of winged, migrating females develops. By this time the gall begins to open, thus allowing the insects to escape and fly. These migrants in turn lay eggs on the trees, and in about 10 days the young develop into wingless males and females and the mature females lay fertile eggs, which remain on the tree until the following spring, when the complicated life cycle is repeated. Most of the known species of this group infest hickory trees.

Itonididae.—Very little is known about the habits of the hickory gall midges except that, where an egg is laid and a larva hatches from it and develops, the plant tissue produces abnormal growth resulting in a larger or smaller gall, constant in shape and in other respects for each given species.

Artificial control.—Under wild or forest conditions artificial control is entirely impracticable and unnecessary, but in the case of valued shade or nut-producing trees that are regularly infested by the galls, it may be desirable to spray the trees with kerosene emulsion (p. 12–13) at the time the buds are opening in the spring, which should kill the stem-mothers or young maggots, as the case may be, and thus prevent the development of the galls.

HACKBERRY GALL-INSECTS.[67]

How injurious.—The galls made by this group of insects occur only on hackberry trees. In general outer appearance these galls do not differ from the almost equally numerous fly galls that occur on these trees, nor are they more injurious. They occur on the leaves, leaf stems, and twigs and, when very numerous, disfigure the appearance of the foliage, but that is about all the harm they do.

[67] *Pachypsylla* spp.

How recognized.—Affected parts bear greater or smaller numbers of protuberances or deformities of various more or less uniform shapes and sizes. These are provided with openings and when fresh contain one or more pink tinged, bluish green, immature insects.

Habits.—The insects in the galls attain maturity in the fall, and in this state pass the winter in cracks of the bark on hackberry or among the débris on the ground. At the time buds on these trees begin to swell and open in the spring the insects begin feeding on the tender growth and laying eggs on the leaves. In about three weeks the eggs hatch and the feeding of the ensuing insects causes swelling of the tissue around them until they are almost completely inclosed. Thus one life round is completed in a year.

Remedies.—In the rare instances when remedial measures are warranted, application of a contact insecticide like kerosene emulsion (p. 12-13) or water-soluble oil (p. 13), at the time the young appear on the leaves in the spring and before the galls are entirely closed, should give considerable relief.

OAK GALL-INSECTS.[68]

How injurious.—Over 400 species of gall-making insects are known to affect oaks, and great is the variety of these galls in shape, size, and structure, all parts of the tree from the root up, including buds, flowers, and fruits, being subject to these deformities. A tree or part of it, particularly its foliage, may be literally covered with the galls of one or more species or may be completely changed by them, and, while the aspect is not always agreeable, the life or health of the tree is never menaced thereby.

How recognized.—Either the size, the shape, the color, or the number of these abnormal growths leads to their ready detection, especially on the foliage. The specific identity of the particular architect, however, can be determined only by the special student of this group of insects. To tree wardens this identity is of secondary consideration, since the injury is so rarely of more than secondary importance.

Habits.—No general outline of the habits applying to all these gall builders can be given. Not all of them are known, and there are too many even of those known for enumeration in this bulletin. Roughly, however, the habits are as follows:

The gall wasps.—In some of the gall wasps a life cycle has been found made up of several generations, only one of which consists of the two sexes. The females of the original generation usually lay their eggs between March and May, and frequently during the period from November to January, while those of the paired generation lay their eggs between June and August. The eggs are laid either on or in the particular portion of the plant they infest, and the developing

[68] Gall wasps (family Cynipidae); gall gnats (family Itonididae).

egg starts and stimulates the growth of the gall around it. The grub which hatches from the egg is footless, creamy or white in color, and feeds, grows, and transforms to the adult four-winged fly in a cell in the gall and then bores its way out into the open.

The gall gnats.—The adult insect is usually a rather small, two-winged gnat, seldom recognized by other than entomologists. In the course of flight the eggs are laid on the surface of the object of attack, which may be leaf, flower, fruit, bud, or stem. Wherever the egg is laid the tissue around it reacts by producing an unusual growth culminating in a closed gall wherein the creamy, greenish, yellowish, or pinkish maggot feeds and may be found while the gall is still green. The pupa is formed within the gall, or else the maggot, upon reaching full growth, drops to the ground and there transforms to the pupa and subsequently to adult fly. There is apparently only one generation a year in most of these flies.

Remedy.—Where some action is imperative—and this can only be true of very highly prized trees after several years of repeated infestation—cutting and burning of gall-laden wood or fallen leaves while the insects are still within the galls is bound to result in considerable benefit if the work is carried out on the infested oaks of a sufficiently extensive area.

RED SPIDERS.[69]

Character and extent of damage.—During a protracted drought the red spider is likely to become very injurious, attacking a great variety of plants. Whole trees, especially seedlings and nursery stock, are apt to have their foliage killed by it.

Evidence of infestation.—Pale brownish spots which may later cover the foliage of the entire plant and a web sometimes so dense as to be plainly visible at a considerable distance appear on the leaves. On examination with a magnifying lens the affected leaves are found to bear numerous, tiny, pearl-like eggs, brownish or reddish little creatures running about, or the glistening empty eggshells and cast skins of the mites.

Seasonal history and habits.—"Red spider" is the name most often applied to two species of web-spinning mites. Mites differ from true insects in having four pairs of legs in the adult stage (fig. 64). They pass the winter as adult females on various wild plants. In the spring they ascend plants and start egg laying at the rate of 5 to 10 eggs a day for a period of 8 to 12 days. During hot, dry weather the eggs hatch, in about 4 days after having been laid, into young mites which commence feeding almost immediately. They reach maturity in 10 to 14 days after hatching, depending on the season and locality. Many generations follow one another in the course of one

[69] *Tetranychus telarius* L. and spp.

summer. Usually by the time their presence is discovered they are already very numerous. They live and feed in colonies and their feeding consists in sucking the juices from leaves.

Remedies.—A stiff stream of water, frequently applied, will rid plants of the red spider in many cases. Individual trees may be sprayed with lime-sulphur (p. 11–12) mixed with soapy water or kerosene emulsion (p. 12, 13). Kerosene emulsion or miscible oil mixed with nicotine sulphate in the usual proportions should also give satisfactory results. Make at least two applications with a 10-day interval between them, the first as soon as the mites appear.

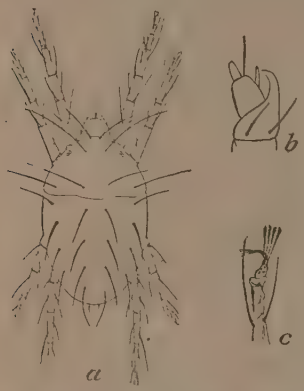

FIG. 64.—Common red spider (*Tetranychus telarius*): *a*, Adult, *b*, palpus; *c*, claws. (Banks.)

GALL-MAKING MITES.[70]

How injurious.—The galls made on shade trees by these microscopic animals are most often located on the leaves or other tender part of the growing plant and, while the affected parts may be badly misshapen or discolored, serious harm to the vitality of vigorous trees is rare.

How recognized.—The mite-made gall is always open and the opening is fringed with hairy growth, or, in fact, the very gall may consist of but a larger or smaller clump of such hairs. In the later stages of development some of these galls assume red and other colors, all invariably turning brown after being deserted by the mites.

Habits.—The mites overwinter hidden under bud scales and probably also bark scales, and start feeding and reproduction early in the spring, in known cases before the buds open. The number of generations produced during the growing season by any given species is not definitely known, but evidently there are several of them. When the food supply on a given spot gives out the mites migrate to another, often covering whole leaves or deforming the buds of entire trees in the course of a season. Their eggs are laid on the surface of the affected area and the feeding is supposed to cause the irritation which produces the abnormal growth. No explanation is yet available for the characteristic gall made by each species of mite, even though produced on the same plant.

Remedies.—Thorough spraying of infested trees during the dormant season with a contact insecticide, like kerosene emulsion (p. 12–13) or miscible-oil solution, should well-nigh exterminate a bad colony.

[70] Family Eriophyidae.

DECIDUOUS SHADE-TREE INSECTS ARRANGED ACCORDING TO THE MANNER OF ATTACK AND KIND AND PART OF TREE SUBJECT TO IT.

ALDER.

See Maple, p. 98.

ASH.

Mite.

Deformed buds_____*Ash-bud gall-mite*, p. 94.

Borer.

Wood of trunk especially near base, honeycombed, burrows packed with granular frass_____*Parandra borer*,[71] p. 61.

BOXELDER.

Sap suckers.

(1) Masses of a reddish bug on tree trunk and branches and a nuisance about dwellings in fall_____*Boxelder plant-bug*, p. 75.

(2) Leaf sap-sucking, licelike insects_____*Boxelder aphis*, p. 85.

BEECH.

Sap suckers.

(1) Masses of bluish-white, woolly aphids on underside of limbs_____ *Beech-tree blight aphis*, p. 87.

(2) Masses of bluish-white, woolly aphids on underside of leaves_____ *Woolly beech aphis*, p. 87.

BIRCH.

Borer.

Reddish or rusty brown spots on white bark of trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows in bark and wood; ridges in the bark on the branches which often develop over the burrows; dying tops of the trees_____ *Bronze birch borer*, p. 59.

BUTTERNUT.

See Walnut, p. 100.

CATALPA.

Leaf chewer.

Leaves eaten by yellow and black striped caterpillars having a short horn near hind end of body; caterpillar droppings beneath trees_____ *Catalpa sphinx*, p. 33.

CHESTNUT.

See Oak, p. 98–99.

COTTONWOOD.

See poplar, p. 99.

ELM

Leaf chewers.

(1) Leaves show holes in early spring; later, abrasions on underside and holes_____*Elm leaf-beetle*, p. 38.

(2) Holes in leaves with spindle-shaped bags near by_____*Bagworm*, p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars up to 2 inches long_____*Spiny elm caterpillar*, p. 48.

(4) Twigs or branches covered with web containing hairy caterpillars. *Fall webworm*, p. 40.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back_____*Forest tent caterpillar*, p. 35.

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[71] This borer is to be found in a great variety of species of both deciduous and coniferous trees.

(6) Leaves eaten by green looping caterpillars or measuring worms—— *Spring canker worm*, p. 36.

(7) White, frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back—— *White-marked tussock moth*, p. 41.

(8) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back——*Large elm sawfly*, p. 51.

Borers.

(1) End leaves turning brown and falling in summer; tops and branches fail to leaf in spring; trunk and branches show patches of dead, easily peeling bark with burrowing, roundheaded grubs beneath it —— *Elm borer*, p. 55.

(2) Twigs wilt and break off, bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk—— *Leopard moth*, p. 68.

(3) Girdled twigs hanging on trees or lying on ground below trees—— *Twig girdler*, p. 71.

Sap suckers.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail——*Oyster-shell scale*, p. 77.

(2) Bark on trunk or branches bearing larger or smaller rough, white, meal-covered knots——*Woolly elm bark aphis*, p. 88.

(3) Branches and trunk, especially at crotches, more or less crowded with stationary brownish insects bordered by cottony white—— *European elm scale*, p. 82.

(4) Cockscomblike growth on leaves——*Gall aphids*, p. 88.

GUM, SOUR.

Borer.

Girdled twigs hanging on trees or lying on ground below them—— *Twig girdler*, p. 71.

GUM, SWEET.

Leaf chewer.

Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back——*Forest tent caterpillar*, p. 35.

HACKBERRY.

Leaf chewers.

(1) Leaves partly or entirely eaten by spiny, black, red-marked, caterpillars up to 2 inches long——*Spiny elm caterpillar*, p. 48.

(2) Leaves being eaten by green caterpillars with pale spots and lines along back and projections on head and rear—— *Caterpillars of hackberry butterflies*, p. 49.

Galls.

On leaves and twigs growths (galls) of various shapes and sizes—— *Hackberry gall insects*, p. 91.

HICKORY.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long——*Walnut caterpillar*, p. 46.

Borer.

(1) Leaves eaten at base of stem; tree sickly, bark inside and surface of outer wood with centipede-like engravings—*Hickory barkbeetle*, p. 72.

(2) Girdled twigs hanging on trees or lying on ground below trees—— *Twig girdler*, p. 71.

Galls.

Abnormal growth on leaves and leaf stems——*Gall aphids*, p. 90.

HONEY LOCUST.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back_____ *White-marked tussock moth*, p. 41.

Borer.

Girdled twigs hanging on trees or lying on ground below trees_____ *Twig girdler*, p. 71.

HORSE CHESTNUT.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back_____ *White-marked tussock moth*, p. 41.

Borer.

Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk_____ *Leopard moth*, p. 68.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail_____*Oyster-shell scale*, p. 77.

LINDEN.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by___*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back_____*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back_____ *White-marked tussock moth*, p. 41.

(4) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back_____*Large elm sawfly*, p. 51.

Borer.

(1) Toward end of summer tips dead and green bark eaten; large irregular burrows made by slender white grub under the bark and deep in the wood near ground_____*Linden borer*, p. 57.

(2) Girdled twigs hanging on trees or lying on ground below them_____ *Twig girdler*, p. 71.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail_____*Oyster-shell scale*, p. 77.

LOCUST.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by___*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back_____*Forest tent caterpillar*, p. 35.

(3) Foliage on tree as if fire scorched; leaves blistered and hollowed out_____*Locust leaf-miner*, p. 43.

Borers.

(1) Trunk and branches gnarled, breaking, and showing wet spots and boring dust_____*Locust borer*, p. 63.

(2) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath_____ *Carpenter worm*, p. 69.

MAGNOLIA.

Sap suckers, scale insect.

Wood of branches sickly, blackened, and underside beset with vivid gray or brown, raised, rather large scales_____*Magnolia soft scale*, p. 81

MAPLE.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by—*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back—*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back—*White-marked tussock moth*, p. 41.

(4) Leaves eaten by smooth, pale yellowish-green caterpillar, lengthwise striped with dark green and with a pair of black "horns" and black pegs along sides and rear end—*Green-striped maple worm*, p. 44.

Borers.

(1) Foliage on limb wilting and dying and sap with some frass oozing from some point on tree; limbs dead, ridges and dead spots on bark; naked scars on trunk near base of limbs; three-eighths to five-eighths inch oval holes at base of tree—*Sugar-maple borer*, p. 53.

(2) Twigs wilt and break off; bark split open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk—*Leopard moth*, p. 68.

(3) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath—*Carpenter worm*, p. 69.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh—*Maple and oak twig-pruner*, p. 70.

Sap suckers, scale insects.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail—*Oyster-shell scale*, p. 77.

(2) On twigs and leaves in summer, white, fluffy cottonlike masses with darker blotch toward one end—*Cottony maple scale*, p. 82.

(3) Tree ailing, bark of trunk and branches more or less incrusted and roughened by stationary, black, circular scales; also white circles—*Gloomy scale*, p. 78.

(4) Tree ailing, twigs blackened and more or less thickly incrusted with raised, reddish scales, ridged along edges—*Terrapin scale*, p. 81.

Sap suckers, aphids.

(1) Abundance of bluish-white wriggling cottony fluff on underside of maple leaves in spring and summer—*Woolly maple and alder aphis*, p. 86.

(2) Leaves discolored and sticky with honeydew and ground beneath trees covered with the same; yellowish green, brown marked, mostly wingless aphids of various sizes with reddish eyes and long hairy antennæ on underside of leaves—*Norway maple aphis*, p. 84.

(3) Leaves more or less densely covered with one or more of the following growths: "Pouch" or "nail" galls (mite made); "eye" spots (fly made)—*Gall insects and mites*, p. 88.

OAK.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by—*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery diamond-shaped spots along the back—*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back—*White-marked tussock moth*, p. 41.

(4) Leaves eaten by looping caterpillars or measuring worms—*Fall cankerworm*, p. 36.

Borers.

(1) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath_____
Carpenter worm, p. 69.

(2) Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk__
Leopard moth, p. 68.

(3) Trees sickly, inside of bark densely scored by frass-filled mines running in al directions_____*Two-lined oak and chestnut borer*, p. 61.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh_____
Maple and oak twig-pruner, p. 70.

Sap suckers, scale insects.

(1) Leaves and tender shoots crumpled up, older leaves and twigs studded with stationary brown, pea-shaped scale insects_____
Pubescent oak Kermes, p. 79.

(2) Tree ailing, smooth bark of trunk and branches more or less incrusted and roughened by stationary black, circular scales; also white circles_____*Obscure scale*, p. 79.

Galls.

Swellings of various shapes and dimensions on upper and under side of leaves or on twigs_____*Oak galls*, p. 92.

PERSIMMON.

Borer.

Girdled twigs hanging on trees, or lying on ground below trees_____
Twig girdler, p. 71.

POPLAR.

Leaf chewers.

(1) Leaves with holes bitten part way or entirely through, later entirely consumed by spotted, soft-bodied, short, stoutish grubs and spotted or striped beetles one-half inch long_____
Cottonwood, poplar, and willow leaf-beetles, p. 50.

(2) Holes in leaves with spindle-shaped bags near by___*Bagworm*, p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars, up to 2 inches long_____*Spiny elm caterpillar*, p. 48.

(4) Leaves blistered or eaten by coiled yellowish-white worms with black line along back_____*Large elm sawfly*, p. 51.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back____*Forest tent caterpillar*, p. 35.

(6) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back_____
White-marked tussock moth, p. 41.

(7) Twigs or branches covered with web containing hairy caterpillars___
Fall webworm, p. 40.

(8) Leaves being eaten by caterpillars with long, soft, drooping, yellow hairs and with five rather long, stiff tufts of black hairs along the back; when at rest, curled up on underside of leaf_____
Cottonwood dagger moth, p. 47.

Borers.

(1) On trunk at crotches irregular scars from which sap oozes and fibrous borings protrude_____*Aspen borer*, p. 58.

(2) Dead or dying limbs, swellings and dead patches of bark often cracked open on limbs and trunk; fading foliage; sawdust and oozing sap at points of attack; injured twigs with burrow along middle with white, fleshy, footless grub at some point_____
Mottled willow and popular borer, p. 65.

(3) Trees breaking, tops sickly, shredded boring dust in piles on ground beneath trees; borer work under bark close to ground——
Cottonwood borer, p. 66.

(4) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish white, greenish beneath——
Carpenter worm, p. 69.

(5) Girdled twigs hanging on trees, or lying on ground below trees——
Twig girdler, p. 71.

Sap suckers, scale insects.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail——*Oyster-shell scale*, p. 77.

Sap sucker, gall-maker.

Leaves bearing prominent swelling on stem and dropping prematurely——
Poplar leaf-stem gall-aphis, p. 89.

SYCAMORE.

Leaf chewer.

(1) Holes in leaves with spindle-shaped bags near by——*Bagworm*, p. 31.

(2) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back——
White-marked tussock moth, p. 41.

Sap sucker, bug.

Leaves off color in spots or entirely; underside shelters colonies of slow-moving, lacelike bugs and their young——*Sycamore lace bug*, p. 74.

TULIP TREE.

Sap sucker, aphid.

Leaves discolored, dropping, with numerous aphids on underside, sticky with honeydew——*Tulip-tree aphis*, p. 85.

Sap sucker, scale insect.

Sickly, blackened branches beset with vivid gray or brown, rather large, high scales——*Tulip-tree soft scale*, p. 80.

WALNUT.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long——*Walnut caterpillar*, p. 46.

WILLOW.

See Poplar, p. 99.

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